United States
CONSUMER PRODUCT SAFETY COMMISSION
Washington, D.C 20207

MEMORANDUM

DATE: February 23, 1998

TO : Linda E. Smith
Project Manager, Range Fires
Division of Hazard Analysis
Directorate for Epidemiology and Health Sciences

THROUGH: Andrew G. Stadnik
Associate Executive Director
Directorate for Engineering Sciences

William H. King, Jr.
Director
Division of Electrical Engineering

FROM : Andrew M. Trotta
Electrical Engineer
Division of Electrical Engineering

SUBJECT: Response to Peer Reviewers' Comments on Range Fires Project Technical Reports

As a first step in launching Phase IV of the Range Fires Project in Fiscal Year 1998, the project team initiated an effort to obtain an independent assessment of the initial phases of the project by soliciting peer review comments on the three laboratory test reports (refs. 1, 2 and 3). Three experts in the areas of fire science and fire protection reviewed the reports and provided comments on the methods used to evaluate pre-ignition conditions, the thoroughness of the studies, and the clarity, organization and appropriateness of data presentation and analysis. The reviewers were also requested to comment on the overall usefulness of the range fire project in providing guidance for developing approaches which could be applied to ranges and cooktops to reduce cooking fires.

The reviewers were Robert Filipczak, a research chemist with the. Federal Aviation Administration (FAA); Edward Clougherty , Ph.D., an adjunct professor at the Worcester Polytechnic Institute (WPI) Center for Firesafety Studies; and James Mehaffey, Ph.D., an associate professor of fire protection engineering at the University of British Columbia (UBC). References 4, 5 and 6 are the reports from the peer reviewers.

Although compilation of the CPSC staff responses to the peer review reports was divided between the Engineering and Laboratory Sciences Directorates, the peer review reports and the accompanying responses were reviewed by all members of the Range Fires Project Team and thus represent a consensus staff position. The two memoranda that document the comments that were excerpted from the reviewers' reports and the associated CPSC staff responses and rationale are enclosed as Attachments 1 and 2. Attachment 1,

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compiled by the Engineering Sciences Directorate with consultation from National Institutes of Standards and Technology (NIST) staff, addresses the comments pertaining to the Phase I and II reports that were written by NIST. Since NIST was not funded for this task, CPSC staff developed the responses in consultation with NIST staff. Attachment 2, prepared by the Laboratory Sciences Directorate, is the response to the comments on the draft report of the Phase III tests, which were conducted at the CPSC laboratory facilities.

In general, the peer reviews were favorable and supportive of the goals and execution of the project. Although each reviewer suggested a number of editorial and technical comments to improve the presentation of the material in the reports, none identified major technical discrepancies. Overall, the reviewers acknowledged that the data analysis results support the conclusions of the three phases of the study. Two of the reviewers recognized that temperature is a potentially reliable pre-ignition indicator. All three reviewers indicated that the data may be useful as a basis for development of control schemes that could incorporate more reliable sensors/detectors in conjunction with thermocouples.

As a result of the peer review effort, the Phase II report from NIST (ref. 2) and the Phase III draft report from CPSC (ref. 3) were revised and finalized. After interested parties have had an opportunity to review the final reports, an industry meeting will be convened to discuss the results. Also, the project team will continue to explore sensor and control technologies that will further enable pre-ignition detection, and develop and test a prototype sensor/control system. The prototype will be based on thermocouples sensing temperatures on the pan bottom.

REFERENCES

1. Johnsson, E. L. ***Study of Technology for Detecting Pre-Ignition Conditions of Cooking Related Fires Associated with Electric and Gas Ranges and Cooktops, Phase I report;*** NISTIR 5729: United States Department of Commerce, 1995.

2. Johnsson, E. L. ***Study of Technology for Detecting Pre-Ignition Conditions of Cooking Related Fires Associated with Electric and Gas Ranges and Cooktops, Phase II report;*** NISTIR 5950: United States Department of Commerce, 1997.

3. **Lim, H.** et al. ***Study of Technology for Detecting Pre-Ignition Conditions of Cooking Related Fires Associated with Electric and Gas Ranges: Phase III [Draft].*** U.S. Consumer Product Safety Commission, 1997.

4. Filipczak, R. ***Peer Review of Technical Reports on Range Fire Testing,*** October 22, 1997.

5. Clougherty, E.V., Ph.D. ***Peer Review of Technical Reports on Range Fire Testing Project,*** October 31, 1997

6. **Mehaffey,** J. Ph.D. ***Peer Review of Technical Reports on Range Fire Testing,*** November 25, 1997.

Attachments

UNITED STATES GOVERNMENT

U.S. Consumer Product Safety Commission
Washington D.C. 20207

MEMORANDUM

DATE: February 12, 1998

TO : Andrew Trotta, ESEE

THROUGH : William H. King, Jr.
Director
Division of Electrical Engineering
Directorate for Engineering Sciences

FROM : Mai Ngo, ESEE

SUBJECT : Responses to Peer Reviewers' Comments on NIST Phases I and II Range Fire Reports

Below are responses regarding comments from the following peer reviewers: Dr. Edward Clougherty of Worcester Polytechnic Institute, Mr. Robert Filipczak of the Federal Aviation Administration, and Dr. James Mehaffey of the University of British Columbia. Comments and responses are divided in first by report reviewed, then by the reviewer. Erik L. Johnsson of the National Institute of Standards and Technology (NIST) was consulted in preparing the the CPSC responses below. NIST has agreed to revise the Phase II report as noted below. The Phase I report had been previously released and while potential improvements are acknowledged, the report itself will not be revised by NIST.

PHASE I REPORT

REVIEWER "A" COMMENTS AND CPSC STAFF RESPONSES ON THE PHASE I REPORT

A Comment #1: "It would be helpful if the report provided some elaboration on what is considered pre-fire conditions as distinct from the normal range of cooking conditions. In other words, are smoke and other visible emissions from cooking considered part of the normal conditions or are they "pre-ignition conditions?" "

CPSC Staff Response: In Phase I, all tests were conducted on a high temperature setting and observed until ignitions occurred. The purpose was to obtain basic data for the pre-fire levels of variables such as temperature, smoke, and organic gases. Phase II provided more information on the comparison of pre-fire to normal conditions. Phase I only determined that

high temperatures, smoke, and gas emissions are pre-ignition conditions. Phase II found that these conditions can sometimes exist for certain normal cooking practices as well.

A Comment # 2: "Is a 200 cfm capacity hood representative of modern residential kitchens or are there substantially higher capacities?"
CPSC Staff Response: Yes. Range hoods come in several sizes from 160 to 440 cfm. Selected hood capacity depends on the size of the kitchen area. 2OOcfm is reasonable for the size of the test room. The NIST test room has an area of 96 sf. Subsequent test phases used a hood with a 350 cfm capacity.

A Comment # 3 : "However, it is somewhat unusual to rely on FTIR measurements for hydrocarbon, carbon monoxide, and carbon dioxide concentrations. Usually, there are dedicated gas analyzers for each of these common gases in enclosure fire tests."
CPSC Staff Response: The concentration of CO_2 (above ambient levels, especially for electric ranges) was expected to be zero before flaming, and CO was expected to be present, but in low concentration. The path integration across the plume of the species signals was expected to provide a better indication of their presence than local plume sampling would. For hydrocarbons, the FTIR was an attractive alternative to a hydrocarbon analyzer because it was nonintrusive and would not experience losses of condensable vapors in the sampling lines. NIST was also investigating whether any other species might show up in the plume since food smoke is not well characterized, and the FTIR was very useful for this.

A Comment # 4: "The absence of any data for CO and CO_2 is a significant shortcoming of the experiments. "
CPSC Staff Response: Attempts were made to collect and analyze CO, data from the FTIR, as explained in the last paragraph on page 49 and section 2.3.2 on page 15.

A Comment # 5: "Another shortcoming is the absence of any installed smoke detectors to see when they would respond."
CPSC Staff Response: Phase I focused on using lab grade sensors to investigate smoke and other particulates . Household smoke detectors were used in subsequent testing in phases II and III.

A Comment # 6: ". . . sugar is normally just one ingredient in a recipe, and is rarely heated alone in a frying pan. The one half pound quantity of sugar is particularly nonrepresentative of actual cooking practice in homes. "
CPSC Staff Response: Although it is not a common practice, some dessert recipes require melting half pound of sugar in a saucepan to make **caramel,** candies, or marzipan. As the test data showed overheating sugar can result in autoignitions at an even lower temperature than oil.

A Comment # 7: " It would have been helpful to follow some recipes requiring extreme heating of vegetable oil, bacon, and particularly sugar in order to distinguish normal-to-extreme cooking conditions from pre-fire conditions with these foods."

CPSC Staff Response: Because the objectives of Phase I focused on evaluation of characteristics of foods near ignition, characterization of normal cooking conditions were outside of the scope of the investigations. However, in Phase II, several cooking scenarios were conducted from a normal cooking period followed by an unattended period leading to ignition by increasing the temperature setting.

A Comment # 8: "It is recommended that a discussion be provided to explain the differences between raw data (with noise level) and smoothed data, and to elaborate on the need to present smoothed data in the report. The raw data presented in Figures 10 through 16 exhibit high amplitude fluctuations following ignition.. . "
CPSC Staff Response: The raw background signals did not show significant noise so signal fluctuations were attributed to natural fluctuations in the measured phenomena, such as random movement of combustion products from the pan contents. High-amplitude fluctuations following ignitions, were due to several applications of cold extinguishing agent to suppress a fire. The method of smoothing is described in the report on page 15 and graphs of smoothed data are marked accordingly.

A Comment # 9: "It would be helpful for the author to describe "when additional smoothing was deemed necessary" as stated at the bottom of the page 15. The suggested discussion would also assist the reader in understanding the need for data processing capabilities in a pre-fire detector. "
CPSC Staff Response: Some signals, such as laser attenuation, had such a degree of natural fluctuations that the trends were (difficult to discern graphically. Smoothing was used to see what the overall trends of such signals were. The criteria for "smoothing was deemed necessary" consisted of a judgment call of whether the trends in time of the raw data were discernible or not. If the natural fluctuations masked the trends, then smoothing was performed to elucidate the trends. Also,, smoothing was employed to clarify relative changes when multiple variables were plotted on the same graph and their raw fluctuations would overlap. For Phase I, data processing or alarm threshold analysis of quantitative signals was not a goal of the research or report. The purpose of that work was to determine candidate signals and qualitative trends and changes as ignition was approached. If smoothing was performed to distinguish trends, then a pre-fire detector may need to mimic the processing capabilities to properly function.

A Comment # 10: The report lacks a clear description of visual observations during the tests. Particularly absent are details of the extent of smoke, fumes, and odor development as the tests progress.. .Addition of photographs . . . and a description of visual observations added to the NIST report Sections 3.1.1 and 3.1.2 for the parametric and instrumented experiments respectively would be helpful in describing the conditions encountered."
CPSC Staff Response: Visual observations were not included in the final report because of cost and time considerations. However, video tapes of all tests and photographs are available.

A Comment # 11: "The data presented do not provide the time to or absence of ignition for

all tests conducted. This information could be presented in a summary table and provided in individual figures for the different variables.. . "

CPSC Staff Response: The majority of phase I testing resulted in ignitions. Although this surnmary would improve the report, the Phase I report contains the ignition data for most tests and is considered sufficient in its present form.

A Comment # 12: "A label affixed to each data graph would improve the identification of the variable, e.g. bacon (fan off) versus oil (fan off) and facilitate analysis and development of conclusions. "

CPSC Staff Response: This comment refers to figures 11, 12, and 19. Their titles include identification of the variable. In some cases labelling each data graph would improve the report further.

A Comment # 13: "Additional figures in which the measured quantities found significant, were presented for particular food/range: combinations would have facilitated the analysis of the results. "

CPSC Staff Response: CPSC staff agree that these figures would enhance the report, but they are not critical to understanding the data.

A Comment # 14: "In assessing the effects of the variables, the discussion could be improved by citing specific results, which are already graphically presented in the preceding text. "

CPSC Staff Response: This would improve the report, but is not critical to understanding the data.

A Comment # 15: "It should be emphasized that the observed result was obtained for one pan material, aluminum clad stainless steel."

CPSC Staff Response: Table 2 on page 7 presents this information. Section 3.7.4, Pan Material, page 58 explains about aluminum clad stainless steel, and the first paragraph of section 5.0, Conclusions, page 65 emphasizes that conclusions pertain to specific combinations of ranges, pans, foods, and ventilation.

A Comment # 16: "No conclusions regarding range type as a test variable are available from the Parametric Experiments shown in Table 1 because five of the six experiments with corn oil were conducted on the gas range."

CPSC Staff Response: The initial parametric experiments shown in Table 1 were used only to select appropriate pans and food amounts for the main experimental series. In Phase I half of the tests were performed on a gas range and half on electric. Range type was selected as **a** variable. for the Phase I experimental series but was not a factor in the parametric experiments preceding the series.

A Comment # 17: "The results obtained for sugar should not be used to assess a general effect of food type as a variable in this study. "

CPSC Staff **Response:** The intent was to represent a range of food types so that an overall

response could be projected.

A Comment # 18: "In comparing the thermal response observed for oil and bacon, the reference to "boiling" should be changed at least to "bubbling" and the discussion should be expanded to include thermal degradation (decomposition) to aerosols, gases and particulate. "
CPSC Staff Response: While boiling can refer to the phase change (liquid to vapor) for many substances including oils, thermal degradation or decomposition is a better choice of words. Phase I will not be revised to reflect this.

A Comment # 19: "The discussion of the effect of the ventilation and capacity to remove smoke by the operation of the range-hoods on the gas and electric ranges would be improved by clearly stating the conditions encountered during test"
CPSC Staff. Response: This would improve the report.

A Comment # 20: "The choice of single pan material precludes the determination of any variable effect due to the pan material. "
CPSC Staff Response: Pan material effects were not an objective in the phase I testing. Phase III testing addressed different pan materials.

A Comment # 21: "The data presented in the report for the Parametric Experiments in Table 1 do not clearly and logically support the choice of the aluminum clad stainless steel pan for the twenty two experiments conducted in this study. "
CPSC Staff Response: While not shown in the table, the primary criteria for selecting aluminum cladding was based on the general low expense of the design relative to all stainless steel (to aim for the center of the consumer range.)

A Comment # 22: "A more complete assessment of the reproducibility for the project would be provided by a Table of the results for the seven duplicated experiments. "
CPSC Staff Response: Although this would facilitate data presentation, the data are adequately presented.

A Comment # 23: "An expansion of the discussion of the frequently observed re-ignition of fires which occurred for oil cooked on electric ranges is important because this phenomenon might be significant in actual fires in homes. Were re-ignition results obtained with the gas range?"
CPSC Staff Response: In this study the burners were de-energized (turned off) immediately after ignition. In the limited number of tests on gas ranges, no re-ignitions were experienced. The re-ignitions on electric ranges may be attributed to thermal inertia. An electric burner continues to heat even after it has been turned off.

A Comment # 24: "Were any extinguishers used in the fires conducted for this project? If so, should not the observations be reported?"
CPSC Staff Response: Yes, page 5 of Phase 1 report refers to a CO_2 extinguisher. The focus of this project was on pre-fire conditions; post-ignition variables were not controlled or

carefully monitored. A test run was ended when ignition occurred. CO, extinguishers were used to suppress the fire and cool down the cooking vessel.

A Comment # 25: "It would have been particularly helpful to provide a brief review of key reports of new detector technology and reports on experiences with existing detectors in or near kitchens. "
CPSC Staff Response: While the scope of work did not provide for a review of key reports, many abstracts from the reports are included in Appendix A when they were available.

REVIEWER "B" HAD NO COMMENTS ON THE PHASE I REPORT

REVIEWER "C" COMMENTS AND CPSC STAFF RESPONSES ON THE PHASE I REPORT

C Comment # 1: "If the lids were removed too early (i.e. before the contents had cooled appreciably) it was noted that the fire could re-ignite particularly for cooking oil. The question is, what would happen in unattended scenarios for which a lid was in place on a sauce pan containing cooking oil (or other foods)? Perhaps temperatures of the pan bottom, pan side or contents would still be useful for assessing the potential for catastrophe (ignition, boil-over, etc.). But how useful would measurements in the plume be? Some experiments with the lid in place would be advisable. "
CPSC Staff Response: Although most incident data revealed lids were not in use, a closed pan is a possibility that would best be addressed by a pan bottom temperature based system.

C Comment # 2: "The parametric experiments outlined in Section 3.1.1 are presumably listed in Table 1 although this is not expressly stated in the section. They are given test numbers **1, 2, 3 . . .** 7 in the table. The instrumented tests outlined in Section 3.1.2 and listed in Table 3 are given numbers 1, 2, 3 . . . 22. That is, there is an overlap in numbering between the parametric and instrument tests. Furthermore, later in the report, the instrumented tests are given two other sets of identification numbers.. . . This all becomes confusing. "
CPSC Staff Response: The 22 experiments in the instrumented tests are numbered in the text as CPSC9501 . . . CPSC9522. These are the bulk of the results. The seven tests in Table 1 were a preliminary parametric plan to select pan materials, and foods were not further considered.

C Comment # 3: "… Pages 2 & 3: The width of the double doorway of the test facility is reported to be 163 cm (64 in) on page 2 and 1.8 m (6 ft) in Figure 1 on page 3. Which is correct? "
CPSC Staff Response: The correct answer is 163 cm (64 in), as stated in the text.

C Comment # 4: " Page 8, Line 7: The statement ". . . its melting point allows faster vaporization . . . " is confusing. Melting refers to the phase change from solid to liquid and vaporization to the phase change from liquid to vapour. A low melting point does not imply faster vaporization. "
CPSC Staff Response: It is true that a lower melting point does not imply faster vaporization. In this context, granulated sugar can vaporize more readily than sugar in vegetable matter.

C Comment # 5: "Page 13, Section 2.2.4, last sentence: What is a set of 64 spectra? Simplify the last sentence to read: " The FTIR data was signal-averaged over 20 second intervals. "
CPSC Staff Response: A set of 64 spectra refers to number of samples averaged in 20 seconds.

C Comment # 6: Page 21, Figure 5: It could be useful to identify the test as Test 5 in Table 3 in the figure caption. **This comment pertains to most of the figures in the paper:** Clearly identify from which tests the data come.
CPSC Staff Response: See Response to A Comment # 22. Many figures include a label (e.g. CPSC 95xx) indentifying the test from which the data originated.

C Comment # 7: Appendices: Why are abstracts included for some references but not for most?
CPSC Staff Response: See Response to **A** Comment #25.

C Comment # 8: Page 76: Replace the title "Temperature Sensors" with "Thermal Sensors" since the list includes papers related to the measurements of heat flux not just temperatures.. . . "
CPSC Staff Response: Thermal sensors would have been a better choice. However, the Phase I Report will not be revised.

PHASE II REPORT

REVIEWER "A" COMMENTS AND CPSC STAFF RESPONSES ON THE PHASE II REPORT

A Comment # 1: "Two minor statements. .. The implication in the first paragraph of Section 2.2.3 is that photoelectric smoke detectors employ laser attenuation, whereas they actually are designed and constructed for light scattering.. . . The second minor misstatement, ... is that light scattering is due to light reflection by smoke particles. "
CPSC Staff Response: Section 2.2.3 refers to "Laser-Attenuation and scattering apparatus, " and not conventional smoke detectors. Some text will be changed to clarify the points on

light scattering.

A Comment # 2: ".. is the implication that volatile organic compound sensors are primarily intended to measure alcohols. In general, volatile organic compounds of sufficient concern to warrant sensor measurements are usually hydrocarbons. "
CPSC Staff Response: On page 19, the Phase II Report simply states how the manufacturers characterized their sensors. It appears that these sensors are essentially the same with different filters. Also, test data show that responses from either the general hydrocarbon or general alcohol sensors were similar.

A Comment # 3: "The description on page 25 of data plotting procedures includes the statement that some data smoothing was employed to avoid difficulties associated with "large signal fluctuations" It is important to elaborate as to whether those fluctuations are signal or data processing noise, or whether they are manifestations of real fluctuations in the measured variables. "
CPSC Staff Response: As stated in the response to A Comment # 8 on page 3, the fluctuations were attributed to the substances being measured and not noise. The smoothing technique is discussed in the Phase I report. The reason for smoothing in Phase II data analysis is included on page 25.

A Comment A # 4: "The report lacks a clear description of visual observations during the forty two (42) tests conducted. Particularly absent are details of the extent of smokes, fumes, and odor development as the tests progressed. Addition of photographs selected from those obtained in the Phase II project and a description of visual observations added to the NIST report would be helpful in describing the conditions encountered. "
CPSC Staff Response: See A Comment # 10 of Phase I.

A Comment # 5: "The decision that gas analyzers and the laser-attenuation systems are not candidates for detector components limited the presentation of results to two experiments shown in Figures 5 and 6 for Tests 22 and 21, respectively. Presentation of additional results could prove useful in later research. Some discussion for the results presented might support the decision to eliminate both measurements as candidates for a pre-fire detector. "
CPSC Staff Response: Although the presentation of additional data from the lab-grade analyzer and laser-attenuation system could prove useful for later research, the primary use for the signals from these instruments was a reference for comparison with the selected sensors. A limited number of representative cases were selected to show the comparative responses between the analyzer and sensor data and therefore focus the discussion on the responses of the selected sensors relative to pre-ignition conditions.

A **Comment** # 6: "In presenting the false alarm data, there was no discussion of food, range type, etc. as possible variables and no attempt to analyze the results for smoke detectors in the manner employed in Table 7 for the: gas sensors. Was there any attempt to perform such an analysis for the false alarm data?"
CPSC Staff Response: The photoelectric smoke detector results could not be analyzed in a

similar way as the sensors because the smoke detectors had a fixed alarm point and only an on/off output signal. The ionization detectors did however have a continuous output despite a fixed alarm point. Neither type of detectors, however, was particularly useful as an indicator of pre-ignition conditions as tested.

A Comment # 7: "On page 73 of NIST Sec. 4.2.3., the author indicates that exploring various combinations of sensor signals can be useful in obtaining better discrimination between fire and non-fire cooking conditions. The problem with this section is the way in which the signals were combined. The maxima and minima from each of two signals over the entire test duration were multiplied, rather than obtaining a running combination of the signals (through multiplication or some more sophisticated combination) as they were recorded. This is not a realistic way of combining signals through some type of real time processing as would be necessary in a multi-sensor detector. "
CPSC Staff Response: Using the maxima and minima was one way to establish a window. If the window is possible, then there are several ways to combine and process signals.

A Comment # 8: "The discussion on food and cooking methods on page 89 states: "The wide range of variations across the 42 tests is indicative primarily of the differences in food and cooking method. " Other than the discussion of false alarm data for gas sensors and thermocouples in Table 7, which ascribed certain anomalies to cooking steak and fish and calculated a reduced false alarm rate, there was no additional commentary. "
CPSC Staff Response: The quotation provided by the comments for page 89 is incomplete. The text proceeds further to state that additional discussion is provided in the "next sections. "

A Comment # 9: "The discussion and analysis is inherently limited because only two gas range experiments, duplicate Tests 35 and 37 and Tests 36 and 38 were conducted with Gas Range B compared to 34 tests conducted with Electric Range A. Furthermore, only Tests 36 and 38, in which chicken was cooked in oil, led to ignition. "
CPSC Staff Response: The test plan focused on electric burners with only a limited comparison with gas burners. Additional testing was conducted by CPSC in Phase III to characterize gas range performance -- the results support the focus on the electric ranges due to thermal inertia effects and faster heating rates.

A Comment # 10: "The results presented for gas sensor experiments with electric and gas ranges in Figure 56 show higher gas sensor voltage and high& rate of rise of gas sensor voltage for the electric range compared to the gas range except for the last 300 to 500 sec. prior to ignition. Is there any significance to the higher gas sensor voltage values? The limited data for experiments conducted with the gas range render further discussion difficult."
CPSC Staff **Response:** In figure 56, the higher gas sensor voltage and higher rate of rise of gas sensor may be attributed to that particular tested electric range heating faster than the particular tested gas range. However, the observation is from four test runs, so generalization about the trend is limited.

A Comment # 11: "The results for 3 tests obtained by laser attenuation measurements

presented in Figure 57 are of limited significance. The use of laser attenuation measurements as a basis for a potential detector for cooking fires was earlier excluded due to cost and bulkiness. Some discussion of the " 1% smoothed" designation appears warranted in view of earlier remarks in Section 3.1."
CPSC Staff Response: Figure 57 was for illustrating a trend only. While a discussion might have improved the text, it was not critical. See also response to A Comment #8.

A Comment # 12: "The discussion and. analysis of results obtained from tests conducted with hood-on and hood-off ventilation over the stove range was limited due to the small amount of data obtained. Additional experiments with other foods and tests conducted with Gas Range B could possibly produce sufficient data to draw significant conclusions. It would be helpful regarding the issue of data fluctuation versus noise in recorded data to comment on the fluctuations shown in Figures 59 and 60. "
CPSC Staff Response: Additional tests could have produced sufficient data for Gas Range B. The fluctuations shown in Figures 59 and 60 are from the measured phenomena. The issue of data fluctuation is addressed in response to A Comment #8 on page 3. Additional airflow experiments were conducted in l?hase III by CPSC.

A Comment #13: "In the first conclusion on page 106, the author should add carbon monoxide and carbon dioxide to the parameters (temperature, hydrocarbons, and particulates) that exhibit higher levels near ignition. This would be based on the results shown in Figures 5 and 6."
CPSC Staff Response: CO and CO, are not appropriate as major species detected before ignition because significant amount of CO and CO_2 are not produced until after ignition.

A Comment # 14: "The first and second conclusions on page 108 would be strengthened by providing examples of the percentages of potential alarms that would result (based on the results in Tables 7 and 8) for detectors in the best and worst locations using conventional threshold sensitivities. "
CPSC Staff Response: The percentages from Tables 7 and 8 were developed from an arbitrary threshold for the purpose of discussion. Thus they do not represent an appropriate criteria for sensor selection.

REVIEWER "B" COMMENTS AND CPSC STAFF RESPONSES ON THE PHASE II REPORT

B Comment #1: "A significant shortcoming of all three reports is the lack of documentation as to the gas sensors used."
CPSC Staff Response: **The** gas sensor names and model numbers will be included in the final Phase II report.

B Comment #2: "What is needed is a sensor that cuts the stove off between the ignition and 30 seconds before ignition."

CPSC Staff Response: CPSC staff disagree with this comment. Based on the Phase II data, it was clear additional performance data from thermal inertia was needed. Phase III experiments evaluated this effect in more detail. The thermal inertia chapter, section 10.2, of the Phase III report, Study of Technology for Detecting Pre-Ignition Conditions of Cooking Related Fires Associated with Electric and Gas Ranges (prepared by the Directorates for Laboratory Sciences and Engineering Sciences) addresses the dangers of shutting off the range 30 seconds prior to ignition conditions. The bounds of the thermal inertia envelope are 120 seconds and a 60°C increase based on the Phase III data.

B Comment #3: "It is not clear why such a limited set of sensors was chosen.. . . . The way to proceed in demonstrating discrimination between near ignition and normal cooking would be to expose the full matrix of sensors to the various scenarios of cooking, much as was done in the experiments contained within the reports.. . . . Further investigation of this technology, which you have already begun to investigate in these three reports, would seem to be warranted."

CPSC Staff Response: Page 19 of NIS'T phase II report lists the criteria and reasons for sensor selection. Some considerations are off-the-shelf availability, cost, geometrical location, and detection potential. Moreover, these sensors were at least 3 years old since testing began. Newer technology sensors are being explored for possible inclusion in any future testing.

REVIEWER "C" COMMENTS AND CPSC STAFF RESPONSES ON THE PHASE II REPORT

C Comment # 1: "Page 24, Table 6: Why is there no site number 12?"

CPSC Staff Response: Site number 12 would have been at the exit to the downdraft exhaust. It was planned initially and included in all of the plans and figures, but it was not implemented. The location is only valid for one range type and therefore would not have been comparable to any other case and was not shown.

C Comment # 2: "Pages 26 & 28, Figures 5 & 6: The site at which these measurements were taken is not mentioned in the figure: or in the text.

CPSC Staff **Response:** **The** site was described on page 9 in Section 2.2.1.

C Comment # 3: Pages 35 & 37, Figures 13 & 14: The detector at Site 5 was the last to respond in Test 22 and the first to respond in Test 16. This should be noted in the text.

CPSC Staff Response: Although this information about smoke detectors could be useful to highlight, it can be extracted from the figures.

C Comment # 4: Page 39, Figure 17: The symbol for thermocouples is T early in the report (see page 13) and changes to TC starting with Figure 17.

CPSC **Staff Response:** Single letter designations were used in the figure to better show the physical locations of the thermocouples.

C Comment # 5: Page 43, Figure 20: The text should at least mention that TC29 shows significant temperature rise.
CPSC Staff Response: TC29's temperature rise was only strong relative to the other shown temperatures, but was not a particularly differentiating signal.

C Comment # 6: Page 49: The last two sentences of the third paragraph cause a lot of confusion primarily because they are out of place. They should be move to become the last two sentences of the second paragraph.
CPSC Staff Response: These paragraphs will be modified.

C Comment # 7: Page 101 and Figure 65: Are the two laser attenuation results actually averaged here?
CPSC Staff Response: Yes, this was stated in the text and figure. (page 101, section 4.4.2)

C Comment # 8: Appendix A: Listing general test and safety procedures in an appendix is preferable to including them in the text as was done in pages 16 & 17 of the Phase I Report. It makes the paper flow better. However, where is Appendix A cited in the text of the Phase II Report. "
CPSC Staff Response: It is mentioned on page 22.

UNITED STATES GOVERNMENT

U.S. Consumer Product Safety Commission
Washington D.C. 20207

MEMORANDUM

DATE: December 24, 1997

TO : Andrew Trotta, Electrical Engineer, Directorate for Engineering Sciences

THROUGH : Andrew Ulsamer, AED, Directorate for Laboratory Sciences AGU (301) 413-0152

FROM : Han Lim, Mechanical Engineer, Division of Engineering, Directorate for Laboratory Sciences (301) 4 13-O 158 12/24/97

SUBJECT : Responses to Peer Reviewers' Comments on CPSC's Phase III Draft Range Fire Report.

BACKGROUND

Robert Filipczak of the Federal Aviation Administration (FAA), Edward Clougherty, PhD. of Worcester Polytechnic Institute (WPI), and Jim Mehaffey, PhD. of the University of British Columbia (UBC) were hired by the U.S. Consumer Product Safety Commission (CPSC) to review CPSC's Phase III Draft Range Fire Report for technical soundness, clarity, and completeness. They were also requested to provide their thoughts for future phases of the range fire project. The purpose of this memorandum is to present the comments from the three reviewers, the CPSC response to each comment, and any changes to the Phase III Draft Report based on the comments.

REVIEWER A COMMENTS AND CPSC RESPONSES

Reviewer A provided many useful comments to the Phase III Draft Report, particularly their comments on water dilution effects and test facility differences. These comments and CPSC's response to each comment are presented below, along with any proposed changes for the Phase III Draft Report.

Reviewer A Comment #1: "...CPSC tests were constructed in a much smaller building compartment than were the NIST tests. The most significant difference is that there was only a 4-inch gap between the front wall of the test kitchen and a solid interior wall in the CPSC

tests...Since air flow into the test kitchen enters through the open double doors in the front wall, the presence of a solid wall only 4 inches away inevitably affected the air flow pattems...This difference is the most likely cause of the different results obtained in the two test facilities when testing the effects of kitchen and range hood air flow."

CPSC Response Ref.: Phase III Draft Report section 8.1 (p.32-33): CPSC cannot quantitatively determine whether there were differences in air flow patterns and if so, whether these were the dominant factor in some of the differences observed between CPSC and NIST test results. Other differences in the two facilities may have contributed to differences in test results, including possible variations (albeit small) in sensor locations and exhaust vent diameters. No changes are required to the existing language in the Phase III Draft Report.

Reviewer A Comment #2: "The ratings are given in BTU/hr for the gas range and in watts for tie other three ranges. It would be preferable for the units to be consistent to facilitate comparisons."

CPSC Response Ref.: Phase III Draft Report section 8.1.3 (p. 36): Table 8.1.3A will be changed so that both metric and English units are shown in the table.

Reviewer A Comment #3: "It would be useful for the authors to provide the manufacturer and model number of the gas sensors used."

CPSC Response . Ref.: Phase 111 Draft Report section 8.2.4. p. 45: The gas sensor names and model numbers will be included in the phase III final report.

Reviewer A Comment #4: "Unlike the NIST reports on Phases I and II, there is no mention of any data smoothing used in Phase III. This is curious since the data plots in the Phase III Draft Report appear even smoother than most of those in the Phases I and II reports."

CPSC Response Ref.. Phase III Draft Report section 8.3 (p.48-49): No data smoothing was performed on the graphs presented in the Phase III Draft Report with the exception of three figures in section 10.7 (Figures 10.7.2A, 10.7.3A, and 10.7.3B). A statement that curve smoothing was performed on three graphs in section 10.7 will be included.

Reviewer A Comment #5: "The assessment of reproducibility between NIST and CPSC results should have been made by computing mean and standard deviations separately for the NIST and CPSC results and comparing values."

CPSC Response - Ref.: Phase III Draft Report section 10.1 (p.51-65): The assessment of comparability was correctly performed since the test facility is the variable. No changes are required to the existing Phase III Draft Report.

Reviewer A Comment #6: "The authors" discussion of the results is limited to a qualitative statement on page 56 that the pan bottom temperatures obtained by CPSC and NIST at

ignition compared reasonably well. A quantitative discussion regarding the agreement of temperature data obtained by CPSC and NIST appears warranted."

CPSC Response - Ref.: Phase III Draft Report section 10.1.3.1 (p.56-59): The data tables and graphs supplied in pages 57 and 58 show that the pan bottom temperatures compared reasonably well. A short quantitative discussion comparing numbers from the temperature data will be added to this section of the Phase III Draft Report.

Reviewer A Comment #7: "It is suggested that the full construction of the pan be provided in the Phase III Draft Report. Are the pans used in phase.111 different from those used in phase I and II?*

CPSC Response - Ref.: Phase III Draft Report section 10.2 (p.66-68): For the phase III tests, CPSC used stainless steel pans with and without stainless steel cladding, ceramic pans, aluminum pans. CPSC and NIST used different pans. If no differences in ignition temperatures were noted between aluminum and stainless steel pans, then pan construction may affect time to ignition, but not conclusions drawn in the Phase III Draft Report. Additional descriptive information on CPSC pans will be included in the Phase III Final Report.

Reviewer A Comment #8: "The general Ihydrocarbon sensor output voltage data presented in Figure 10.2A for Test 28 appear to be smoothed; for Test 27, the data are not smoothed. Similarly in Figure 10.2B, the data for Test 19 appear smoothed; for Test 20, the data are not smoothed Is the fluctuation shown for Tests 27 and 20 a result of noise?"

CPSC Response - Ref.: Phase III Draft Report section 10.2 (p.67): The fluctuations in Tests 27 and 20 are not a result of noise. No curve smoothing was performed in any of the figures mentioned in this comment. This issue is addressed in Reviewer A comment #4.

Reviewer A Comment #9: "...the last sentence in the first paragraph on page 79 says there wasn't any difference between high heat and medium-high settings. However, the executive summary of that section on page 7 says that sensor responses for medium-high settings "were actually greater than sensor responses for high heat cooking tests which did ignite."

CPSC Response - Ref.: Phase III Draft Report section 10.5.1 (p. 76-79): The statement in page 7 of the Phase III Draft Report needs to be more specific in that this observation applies primarily to aluminum pans. The statement on page 79 needs to be similarly qualified. The effect was only seen occasionally with stainless steel pans, while ceramic pans exhibited mixed behavior. The Phase III Draft Report will be corrected in pages 7 and 79.

Reviewer A Comment #10: "...decreases in gas sensor readings due to range hood and ceiling fan air flows are more severe than those obtained at NIST, but they don't have an explanation for the differences observed. The explanation clearly lies in the different types of air flow in the two facilities, due in part to the restricted air flow through the kitchen doors in the CPSC

facility. and in part to the larger ceiling fan used in the CPSC facility."

CPSC Response . Ref.: Phase III Draft Renort section 10.6 (p.84-89): NIST did not conduct tests in phases I and II with ceiling fans. NIST did however report some effects on gas sensor responses from the use of a range hood in Phase II. The reasons for the differences in range hood results are not clear at this time, but may reflect subtle differences in gas sensor pair placement. CPSC found that a combination of range hood and ceiling fan showed the greatest decreases in gas sensor responses. Appropriate language will be added to section 10.6 to address this issue.

Reviewer A Comment #11: "The authors did not discuss the possible cause for the reduced signal which indicates lower concentrations of cooking gases most likely due to a dilution effect from water vapor."

CPSC Response .Ref.: Phase III Draft Report section 10.7 (p.90-95): Reviewer A makes a valid point since the presence of water vapor was a variable to be examined and a direct comparison to an oil only test was made. Water vapor could have caused a diminution of gas sensor signals either by dilution and/or oil particle enlargements due to condensation with water. Appropriate language will be added to section 10.7.

Reviewer A Comment #12: "The authors are being unnecessarily (and perhaps unfairly) harsh on the smoke detectors. First, it is widely understood that smoke detectors should not be placed near a kitchen range if false alarms due to cooking aerosols are to be avoided."

CPSC Response. Ref.: Phase III Draft Report section 10.9 (p. 100): Yes, it is true that in common practice, smoke detectors should not be placed near a kitchen range since nuisance alarms can occur. However, CPSC tested the smoke detectors in a kitchen range environment to determine their potential for producing usable pre-fire signals. Section 10.9 of the Phase III Draft Report presented an objective view on the performance of the smoke detectors in the way CPSC used the smoke detectors, CPSC found that the smoke detectors as used in this study were not useful for pre-fire detection. This does not means that smoke detectors for use in pre-fire applications are not possible. No changes are required to the existing language in the report.

Reviewer A Comment #13: "...all the photoelectric detectors apparently did successfully alarm either prior to or soon after ignition providing they were situated in the path of the smoke. . . "alarming at two minutes or less can be too close to ignition for successful intervention" may be true for certain fire scenarios, but it is not true for many other scenarios."

CPSC Response · Ref.: Phase III Draft Report section (p. 100-1 (4): To guard against as many fires as possible, a reasonable reference point of 2 minutes prior to ignition was chosen based on the thermal inertia envelope described in CPSC's response to Reviewer B's Comment #5. Although an elaborate discussion of the individual test runs was not presented in the Phase III Draft Report, the data analysis for all of the photoelectric detectors that did alarm prior to

ignition did not show pre-fire signals during the phase III tests. Factors that influenced the scatter of the photoelectric responses included air flow effects, various types of pan contents, pan position, etc. No changes are required to the existing Phase III Draft Report.

Reviewer A Comment # 14: "... combining pan bottom temperature with rate-of-temperature-rise as a basis for controlling range operation.... authors' recommended delineation based on the boundary between ignition and no-ignition test results. The problem with their recommended delineation is that it allows for range operation at higher temperatures when there is a positive rate-of-rise than when there is a negative rate-of-rise. This is both counter-intuitive and inherently unsafe."

CPSC Response · Ref.: Phase III Draft Report section (page 110): These data have been re-analyzed and a new Figure 11.3A will replace the existing figure. The discussion will be appropriately revised to reflect the changes in the figure and address any of the remaining concerns.

REVIEWER B COMMENTS AND CPSC RESPONSES

Reviewer B comments on CPSC's Phase III Draft Report were relatively few in number. These issues are discussed below along with proposed changes to the Phase III Draft Report.

Reviewer B Comment #1: "A significant shortcoming of all three reports is the lack of documentation as to the gas sensors used.."

CPSC Response . Ref.: Phase III Draft Report section 8.2.4 (p. 45): As stated in the response to Reviewer A comment #3, this will be done.

Reviewer B Comment #2: "Some of the sensor data, which were undoubtedly gathered, were not presented and some of the data presented does not lead to useful conclusions."

CPSC Response · Ref.: Phase III Draft Report section 8.2.4, D. 45: As explained on page 51 of the Phase III Draft Report, representative data were presented to illustrate major findings or trends found in the tests. Only the detection devices that showed the ability to produce usable pre-fire signals were chosen for analysis. The rationale for the selection of key detection devices is presented in section 10.1 of the Phase III Draft Report. No changes to the Phase III Draft Report are needed to address this comment.

Reviewer B Comment #3: "A dangerous situation does not yet exist in the cooking of 500 ml of soybean oil when the food temperature is only 288°C... you looked for the lowest temperature at which ignition could occur for all types of food and used that as the do not exceed condition. Then you looked at what the sensor data tells you at that temperature, and predictably it tells you nothing since you are not near an ignition condition...The 288°C standard for electric fry pans is appropriate for that kitchen device, but a kitchen range is a

much more versatile piece of equipment and the temperature is most probably too limiting."

CPSC Response · Ref.: Phase III Draft 'Report section 10.5.1 . p. 76-79; In section 10.4 of the Phase III Draft Report, three reasons were given for choosing to evaluate the gas sensor data at 288°C pan content (i.e., food) temperature. These reasons were on the pan bottom temperature analysis at ignition, the UL standard for electric frying pans, and Good Housekeeping's recommendation for cooking temperatures. On page 76 of the Phase III Draft Report, it is stated that a pan content temperature of about 300°C represents a 99% probability of not achieving ignition based on the phase III data. A pan content temperature of 288°C was also used as a reference point for gas sensor analysis because caramelized sugar can ignite at a pan content temperature of 288°C. No changes to the Phase III Draft Report are required to address this comment.

Reviewer B Comment #4: 'The data which is needed to determine sensor effectiveness is the change of sensor output from baseline...Tables 10.1.3.2 A-D attempts to do this but baseline voltages changes do not appear to be subtracted, so a direct comparison cannot be made."

CPSC Response . Ref.: Phase III Draft Report section 10.1.3.2, p.62-63: CPSC staff agrees that this would be a reasonable representation of the data. The data will be re-analyzed in the section 10.1.3.2 tables; tables with the baseline voltages subtracted will substitute the tables in pages 62 and 63 and appropriate text changes will be made.

Reviewer B Comment #5: "What is needed is a sensor that cuts the stove off between the ignition and 30 seconds before ignition."

CPSC Response: The thermal inertia chapter of the Phase III Draft Report (section 10.2) addresses the dangers of shutting the range off at 30 seconds prior to ignition. An ignition is likely to occur 30 seconds prior to ignition due to thermal inertia effects. No changes to the Phase III Draft Report are required to address this comment.

Reviewer B Comment #6: Reviewer B makes a number of detailed comments suggesting use of the new "electronic nose" technology. He also supplied technical literature on this technology with their peer review report.

CPSC Response: Currently, CPSC staff is updating the patent and technology search to determine if there have been further advances in detection devices in the past three years. The '*electronic nose" technology will be considered in this update.

REVIEWER C COMMENTS AND CPSC RESPONSES

In addition to the general technical comments, Reviewer C also provided CPSC staff detailed editorial comments for the entire Phase III Draft Report, particularly comments on thermal inertia issues and air turnover rates. Reviewer C's comments are discussed below, along with any changes to the Phase III Draft Report.

Reviewer C Comment #1: "...As most engineering and scientific communities around the world use the metric system. it would be helpful if metric equivalents were provided..."

CPSC Response: All English units in the phase III report will be expressed with their metric equivalents.

Reviewer C Comment #2: "It is implicitly assumed that the temperature data at ignition satisfies a normal distribution..."

CPSC Response . Ref.: Phase III Draft Report section 10.4 (p. 73): A statement describing that the ignition temperature data follow a normal distribution will be included.

Reviewer C Comment #3: "...It is mentioned that 65% of cooking oil and grease fires involved the **temporary** absence of cooks. Yet there are some of the tests involving cooking oils, the unattended portions are very long...Do the statistics justify using the term temporary?

CPSC Response. Ref.: Phase III Draft Report section 1 0.(p.1): Clearly, incident fires occur in the absence of cooks (or unattended cooking). Temporary is a relative term used to describe this absence. "Temporary" will be removed from the above statement.

Reviewer C Comment #4: "...Air currents induced by the ceiling fan and/or the range hood reduced gas sensor signals to 5-1 0% of the signal obtained when no air movement occurred (page 114). It is puzzling that the effect, at least as far as the fume hood is concerned, was not observed in the phase I and II tests. Could some of this effect be due to the fact that the test facility draw air from a very large building in phase I and II tests conducted at NIST but from a building of much smaller dimensions at CPSC?"

CPSC Response: Responses to Reviewer A's comments #1 and 10 address this issue. NIST's Phase II study did see effects from range hood operation on gas sensor responses. CPSC did not quantitatively determine that differences in air flow patterns were the dominant reason for the differences in gas sensors responses between the NIST and CPSC tests. The phase III report indicates that the sensor responses were generally comparable overall.

Reviewer C Comment #5: "Were the air turnover rates measurements using SF, injection (page 34) taken in the absence of air flow?"

CPSC Response; Yes, but in the course of reviewing these data, it was decided that they were so limited that the sentence regarding similarities of the SF, measurements should be removed from section 10.1 of the Phase III Draft Report. Air movement in both rooms would be controlled either by heat or forced air movement and SF, measurements were not taken under these conditions.

Reviewer C Comment #6: "To account for thermal inertia effects, the report recommends that an electric range be shut off (or cycled) when the pan bottom temperature reaches 340°C on

page 65. 100. 106, 108. and 113. On pages 11. 75. and 104 a value of 330°C is mentioned. The reference to 330°C should be changed to 340°C."

CPSC Response: The value of 330°C will be changed to 340°C in the appropriate places that Reviewer C mentioned in this comment

Reviewer C Comment #7: Reviewer C suggested 12 relatively minor editorial comments listed in pages 6 and 7 of their peer review report.

CPSC Response: The'editorial comments will be incorporated.

CONCLUDING REMARKS

The comments of the reviewers were useful to staff and served to strengthen the Phase III Draft Report. The authors are grateful to the reviewers for their comments.

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6. Mehaffey. J. PhD. of University of British Columbia. *Peer Review of Technical Reports on Range Fire Testing, 1997.*