Tab C

Residential Fires Involving Mattresses and Bedding

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

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Executive Summary

In 1998, the National Institute of Standards and Technology (NIST), with the sponsorship of the mattress industry and the encouragement and support of the U.S. Consumer Product Safety Commission (CPSC), began a study of the fire behavior of bed assemblies that included mattresses, foundations, and bedclothes. The NIST report concluded that it is feasible to manufacture mattresses that produce levels of peak heat release lower than the levels produced by mattresses currently on the market, when the mattress is subjected to an open flame similar to that of burning bedclothes. NIST test results indicated that ignition of a mattress of this design would have the effect of increasing the time available for room occupants to escape, from less than 5 minutes to 10 to 15 minutes, before conditions in the room become untenable. In addition, the likelihood of flashover would be minimized during the first 30 minutes, thus delaying spread of the fire to other areas of the occupancy and allowing more time for occupants to escape.

In October 2001, CPSC published an Advance Notice of Proposed Rulemaking to develop an open flame standard for mattresses, based largely on the NIST work. The test requirements being considered are expected to reduce fire losses resulting from mattress/bedding fires caused by smoking and some other ignition sources, as well as fires started by open flames. This report presents the CPSC staff's evaluation of the effect of the draft proposed standard on mattress casualties. Since the draft standard is designed to limit fire intensity and spread rather than prevent fire ignition, the report focuses primarily on reduction of deaths and injuries.

Evaluation of effectiveness was based primarily on review of CPSC investigation reports that provided details of the occupants' situations and actions during the fire. Staff reviewers identified criteria that affected the ability of occupants to escape the fires they experienced. These criteria were used to estimate percentage reductions in deaths and injuries expected to occur under the much less severe fire conditions anticipated with improved mattress designs. The estimated reductions then were applied to national estimates of mattress/bedding fire deaths and injuries to estimate numbers of deaths and injuries that could be prevented.

Potentially Addressable Fire Losses, Based on Fire Cause

- Based on national fire estimates for the years 1995 – 1999, ignition of mattresses and bedding resulted in an estimated 19,400 residential fires, 440 deaths, 2,230 injuries, and $273.9 million in property loss annually. Based solely on the characteristics of fire cause, an estimated 18,500 fires, 440 deaths, 2,160 injuries, and $259.5 million property loss annually were considered potentially addressable (potentially preventable) by the draft proposed standard.

- Among the potentially addressable casualties, smoking fires accounted for 210 deaths (48 percent) and about 640 injuries annually (30 percent). Open flame

fires accounted for about 140 deaths (32 percent) and 1,050 injuries annually (49 percent).

- Children younger than age 15 accounted for an estimated 120 addressable deaths (27 percent) and 500 addressable injuries annually (23 percent). Adults age 65 and older accounted for an estimated 120 addressable deaths (27 percent) and 250 addressable injuries annually (12 percent).

Potential Reduction in Fire Losses, Based on Victim Characteristics

- Expected reductions in deaths and injuries varied somewhat by age group. Deaths and injuries to children ages 5 and younger were estimated to be reduced by 85 to 92 percent and 80 to 87 percent, respectively. Deaths and injuries to children ages 5 to 14 were estimated to be reduced by 94 to 97 percent and 88 to 94 percent, respectively. Deaths and injuries to adults age 65 and older were estimated to be reduced by an estimated 69 to 75 percent and 87 to 91 percent, respectively.

- Among upon investigated fires not weighted to national estimates, deaths estimated to be prevented varied by location of the casualty at the time of the fire. When casualties were at the point of ignition, 66 to 75 percent of deaths were expected to be prevented. When the casualty was in the room of origin but not at the point of ignition, 87 to 93 percent of the deaths were expected to be prevented. When the occupant was not in the room of origin, 99 percent of all deaths were expected to be prevented.

- Overall, CPSC staff estimates that the draft proposed standard may be expected to prevent 80 to 86 percent of the deaths and 86 to 92 percent of the injuries presently occurring in addressable mattress/bedding fires attended by the fire service. Applying these percentage reductions to 1998 – 2002 estimates of addressable mattress/bedding fire losses, we estimate potential reductions of 310 to 330 deaths and 1,660 to 1,780 injuries annually in fires attended by the fire service.

It is noted that the range of percentage reductions cited above reflects the range of assigned probabilities attached to the general categories of "likely", "possible," and "unlikely" deaths or injuries remaining, as developed by CPSC staff reviewers. They do not represent statistical confidence intervals.

Additional discussion of the role of bedding items in mattress fires is contained in a separate tab of this briefing package.

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I. Background

In October 2001, CPSC published an Advance Notice of Proposed Rulemaking to develop an open flame standard addressing mattress fires. A number of events are related to this decision.

- CPSC granted two petitions from the Children's Coalition for Fire-Safe Mattresses.
- The mattress industry, with the encouragement and support of CPSC staff, sponsored research at the National Institute of Standards and Technology (NIST) to test the feasibility of producing mattresses that would be resistant to small open flame sources.
- The California Bureau of Home Furnishings incorporated the NIST test into their revised TB 603 to address open flame ignition. That standard is expected to take effect in January 2005.

Research conducted by NIST [1] indicated that it is feasible to develop mattresses that can withstand application of an open flame source, will limit peak heat release to minimize the likelihood of flashover,[2] and provide occupants of the room 10 to 15 minutes to escape before conditions in the room become untenable. It is anticipated that in that time period, there will be smoke in the room of origin which will extend from the ceiling to about three to four feet from the floor, requiring people to crawl to exit the room. The heated air present in the room of origin would not be lethal to breathe during this time period. NIST data indicate that a test period of 30 minutes will be sufficient to pass only mattresses that will produce the above effects. Currently, fires involving mattresses produce much higher heat release and air too hot to breathe in less than five minutes following ignition, allowing little time to escape.

CPSC is now in the process of developing a proposed rule to address open flame ignition of mattresses. This document has been prepared to evaluate the effect on fire losses if the involved mattresses meet the test conditions described above. The nature of the test method being proposed by CPSC staff is expected to reduce losses caused by smoking and other ignition sources as well as open flame sources. It is noted that the staff's draft proposed standard will mitigate the effects of mattress fires but not prevent the fires from occurring. Therefore,

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[1] Ohlemiller, TJ et al, "Flammability Assessment Methodology for Mattresses," NISTIR 6497, June 2000 and Ohlemiller, TJ and Gann, RG, "Estimating Reduced Fire Risk From an Improved Mattress Flammability Standard,", NIST Technical Note 1446, August 2002.

[2] Flashover is the point in a room fire at which radiant heat from the hot smoke accumulating in the upper portions of the room ignites all flammable materials within the room and may extend outside the room.

evaluation of the effectiveness will be limited to reduction of deaths and injuries. While property damage will also be reduced, it is not possible to estimate the extent of that reduction.

The ignition of bedclothes is an integral part of the mattress fire hazard and is discussed in a separate tab in this briefing package.[3]

II. Methodology

A. General

Evaluation of the effectiveness of the draft proposed standard was developed by first estimating current residential fires and fire losses associated with mattresses and bedding (bedclothes) based on the most recent national estimates of fire service-attended fires. Since those estimates are based only on coded data, CPSC staff also reviewed CPSC and fire department investigation reports to determine the significant details involved when people died or were injured in mattress/bedding fires. From this review it was possible to identify a number of factors that adversely affected the ability of occupants to escape the fire safely, and to estimate whether the deaths and injuries that occurred could have been prevented or reduced in number under the conditions of the draft proposed standard. National estimates of expected reductions in casualties were developed by applying the expected percentage reductions of deaths and injuries within subsets of the investigations to equivalent subsets of the national estimates of fire service attended fire losses. The national estimates of subset reductions were then summed to obtain an overall estimate of deaths and injuries in fire service-attended fires that could be prevented.

B. Current National Estimates

1. Fire Losses Attended by the Fire Service

Annual estimates of national fires and fire losses in which a mattress or bedding ignited first were based on data from the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA) annual survey of fire departments. The NFPA survey is a stratified random sample of fire departments that produces national estimates of total residential structure fires and fire losses. It does not, however, provide data on product involvement.

The NFIRS is a data system to which participating fire departments across the country voluntarily report data on the fires they attended, providing details of product involvement. Since the NFIRS is not a probability sample, NFIRS data were weighted to the NFPA national estimates to produce product-specific estimates. In recent years, approximately one-third to one-half of U.S. fire departments participated in NFIRS.[4] A general description of the estimation

[3] "Involvement of Bedclothes in Residential Mattress Fires, May 2004, Linda Smith/EPHA

[4] For additional detail on NFIRS, see "Fire Loss in the United States," National Fire Data Center, U.S. Fire Administration, Federal Emergency Management Agency, produced annually.

procedure is described in Hall and Harwood. [5] National estimates in this report reflect residential structure fires, except for intentional fires and fire losses and fire fighter casualties.

NFIRS Coding System Revision:

The NFIRS coding system recently underwent a major revision that took effect with 1999 data. Many of the reporting variables and reporting procedures changed, with the result that data from the two systems are no longer directly comparable and are not amenable to tracking trends. To adjust for this situation, estimates presented are five-year averages (1995 – 1999), produced for single years, averaged, and rounded.

Editing and Addressability:

Several NFIRS variables were used to determine whether an incident was a mattress or bedding fire, determine an incident's addressability by the draft proposed standard, identify intentional fires (excluded from the estimates), determine a fire's heat source type (smoking materials, small open flame, other), and break down estimates based on age and location of the victim. The NFIRS variable "Form of Material First Ignited" (1995 – 1998) and its 1999 equivalent "Item First Ignited" were used to identify mattress and bedding fires. The codes counted as mattress or bedding for both of these variables were '31 – mattress, pillow' and '32 – bedding, blanket, sheet, comforter'.

Since several variables are used in NFIRS to capture the characteristics of each fire, it was possible that the coded values could be inconsistent in producing an accurate picture of the situation. When they were not consistent, it was felt that the cause was usually miscoding of one of the variables. Nevertheless, when this occurred, to be conservative, CPSC staff assumed for this analysis that it was always the mattress/bedding variable that could not be relied upon. Any such incidents were edited out and not counted as mattress or bedding fires. Thus, an incident citing the "Area of Origin" code "escalator" would not be counted as a mattress fire. Appendix Tables A1 and A2.1 – A2.3 include the list of codes edited out and the codes considered as mattress/bedding incidents, both addressable and not addressable. The term "addressable" refers to incidents expected to be affected by the proposed mattress standard, based solely on the characteristics of fire cause. NFIRS codes cited in Tables A1 and A2 refer to the pre-1999 data system. Although the 1999 codes are not cited in Appendix A, the types of incidents in each category remained the same in 1999 as in previous years.

As stated above, estimates of fires attended by the fire service combined the mattress and bedding codes since it was uncertain whether the fire service routinely could distinguish which ignited first. However, NFIRS captures only the item first ignited. Thus, if a fire coded as igniting bedding did not also involve a mattress (a non-addressable situation), it could not be conclusively identified from the NFIRS data alone.

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[5] John R. Hall, Jr. and Beatrice Harwood, " The National Estimates Approach to U.S. Fire Statistics," Fire Technology, May 1989, Volume 25, Number 2, pp 99 – 113.

Staff review of the NFIRS data to explore this issue identified the laundry room as the only location in which there were a disproportionate number of bedding ignitions compared to mattress ignitions as the first item ignited. Slightly over half of these bedding fires involved clothes dryers, suggesting a laundering process that separates bedding from the mattress. Bedding fires in laundry rooms overall involved about 1.5 % of all mattress and bedding fires. Review of the casualty data, however, indicated that no deaths and less than one percent of the mattress and bedding injuries were associated with bedding ignitions involving clothes dryers. Therefore, it is concluded that although the addressable mattress and bedding fire estimates could include a small proportion of non-mattress fires, a negligible number of non-mattress injuries and no non-mattress deaths were included within the estimates of addressable deaths and injuries.

In general, the draft proposed standard is expected to address not only fires caused by traditional small open flame sources such as lighters, matches, and candles, but also other small open flame sources, smoking material fires (in conjunction with FR 1632), and ignition sources such as fires caused by proximity to a heat source. The variables used to determine whether a mattress or bedding fire was addressable were "Ignition Factor," "Equipment Involved in Ignition", and "Form of Heat of Ignition" (or "Heat Source" for 1999). It is noted that regardless of initial heat source, investigation data indicated that once a fire ignited, the bedding present also ignited, which would produce a flame similar to that used in the NIST tests.

There were some ignition factors that made an incident not addressable only when the "Form of Heat of Ignition" was smoking materials, a candle, a match, or a lighter. These included 'cutting, welding too close to', 'short circuit, ground fault', and 'backfire,' which could not be possible malfunctions for these products. There were some "Equipment Involved with Ignition" codes that caused any mattress or bedding fire to be not addressable. Some of the Equipment codes that made a fire not addressable were conveyors, printing presses, processing equipment, and service or maintenance equipment (with the exception of torches). NFIRS coding conventions precluded specifying a piece of equipment when the fire involved smoking material, a candle, a match, or a lighter.[6] Incidents that did not follow this convention were considered not addressable. Some "Form of Heat of Ignition" ("Heat Source" in 1999) codes made an incident not addressable. These included bonfires, explosives, incendiary devices, and others.

A vast majority of incidents coded as a mattress or bedding fire in the NFIRS data base were counted as such – few were edited out. Similarly, a vast majority of mattress and bedding fire incidents were deemed addressable by the draft proposed standard.

In view of the major changes made to the 1999 NFIRS, this report presents averaged NFIRS-based estimates for the most recent five-year period available, rather than for each year separately. NFIRS 1999 was the first year in which the file distributed by USFA used the newer

[6] NFIRS states that fires involving smoking material, candles, matches, or lighters should be coded "no equipment involved."

NFIRS 5.0 version. Data reported from departments still using the older 4.1 version in 1999 were converted to the new version to the extent possible and represented a major part of the file.

In NFIRS 5.0 (1999) all causes of arcing falls under one heat source code. In 4.1 (1998 and previous) there were six codes for arcing and one of these was considered 'Additional Small Open Flame' whereas the other five were considered 'Other In-Scope Ignition'. In 5.0, staff cannot distinguish between the different causes of arcing so they were all considered 'Additional Small Open Flame' for this analysis. The 1999 estimate for 'Additional Small Open Flame' is considerably higher than in the past and the 1999 estimate for 'Other In-Scope Ignition' (which includes Radiated Heat from Operating Equipment, Hot or Smoldering Object, Heat from Powered Equipment, etc.) is considerably lower than in the past for this reason.

Allocation of Unknowns

It was possible to have "unknown" values for each of the NFIRS variables used for this analysis. A technique known as raking was used to allocate "unknown" values among the known values for each variable. This technique is described in detail in Appendix B.

C. CPSC Investigation Reports

In-depth investigations were conducted by CPSC field staff to provide detailed information about the fires that ignited mattresses and bedding. Most such investigations also included documentation from the fire department that attended the fire. Nearly half of the investigated deaths were identified from death certificates with follow-up reports from the fire department. Investigations used for this report were limited to fires in which a mattress or bedding was reported as the first item to ignite, the fire was of the type considered addressable by the draft proposed standard, and a civilian death or injury resulted. These incidents were further limited to those that occurred during 1999-2004 and entered into a CPSC data base by June 30, 2004. A total of 195 deaths and 205 injuries that occurred in fires attended by the fire service were included. See Appendix Tables D-1 (deaths) and D-2 (injuries). In addition to investigation reports initiated from death certificates, incidents were selected for investigation based on a variety of CPSC staff interests during this time period. This included fires initially reporting involvement of mattresses or bedding, fires ignited by candles or lighters, and a variety of other fire ignition sources. Most fires involved the ignition of both bedding and mattresses but no incidents that involved solely bedding were included among the investigations used to evaluate effectiveness. As a result of the investigation assignment process, the distribution of mattress ignition sources is not representative of all mattress-involved fires. To accommodate this situation, results within subsets of the investigation data (by heat source and victim age group combinations), deaths and injures separately, were applied to matching subsets of the NFIRS-based national estimates.

D. Estimation of Death and Injury Reduction

Step 1) Review investigation reports to assess likelihood of post-standard death or injury

Evaluation of whether a particular death or injury would be prevented by the staff's draft proposed standard was based on detail cited in the investigation report. Most mattress/bedding incidents used for this report were ignited by small open flame sources such as lighters or candles, or other equipment-related fires which were of interest to CPSC staff during this period. Relatively few smoking-related incidents were included compared to the proportion of smoking incidents contained in the national fire data.

Evaluations of the fire incidents by CPSC staff reviewers assumed the following scenario which was based on the results of NIST testing conducted to assess the hazard produced from the burning mattress and bedclothes.

- Occupants in bed when the fire ignited but able to escape the burning bedclothes in the first 3 to 5 minutes were expected to be subjected to a minimal hazard.

- Occupants in direct contact with burning bedclothes for a longer period would be subjected to potentially hazardous levels of heat release that would peak at about 5 to 10 minutes after ignition.

- If the burning bedclothes did not ignite other non-bedding items in the room or produce flashover in this time period, heat release would subside temporarily and then begin to increase again as the involvement of the mattress increased.

- Assuming the conditions above, occupants would have a total of about 10 to 15 minutes to escape the room of origin before the situation in that room became untenable.

- Assuming that the mattress design was capable of withstanding the threat from the bedclothes and that the bedclothes did not contribute enough heat to pose a hazardous condition, the draft proposed mattress standard was expected to minimize the likelihood of flashover during the first 30 minutes. As a result, occupants in other rooms would not be confronted by the intense heat and smoke experienced by those in the room of origin during this period.

Thus, it was expected that no deaths would occur among people who were outside the room of origin at the time of ignition, unless they entered the room of origin during the fire or were incapable of exiting the occupancy on their own, e.g. those who could not move on their own.

Each investigation was evaluated by three CPSC staff reviewers[7] to identify the features related to the occurrence of a death or injury. In order to categorize individual incidents, a set of criteria was developed to standardize decision-making. These criteria captured a variety of factors that appeared to affect the likelihood of death or injury, taking into account the characteristics of the fire, the fire source, the characteristics and behavior of the casualty, and the other members of the household who were present (Appendix C, Tables C-1 and C-2). The primary criteria considered were the following:

- the location of the casualty in relation to the point of fire origin,
- the age of the casualty
- whether the casualty was asleep, awake, or unable to act on his own due to extreme age (young or old) or disabilities,
- if the casualty was asleep, whether there was an indication that the person woke up (evidenced by being found not on the bed),
- if the casualty was of extreme age or disability, whether there was a potential rescuer in the household,
- presence of any other limiting conditions (less severe) that would be expected to reduce the casualty's ability to escape, e.g., drugs, alcohol, mental or physical limitations,
- whether the casualty engaged in fighting the fire.

The presence of a rescuer was considered critical for children ages 2 and younger since they do not have adequate cognitive or motor abilities to extract themselves from the fire area. The ability of children ages 3 to 4 to leave the fire area on their own was considered uncertain even though they have better cognitive development and are more independent. While children ages 5 to 9 should mostly have been able to escape on their own, several reports stated that children of this age group ran into other rooms or broke away from exiting family members. Rescuers were considered critical for those aged 85 and older primarily because of the likelihood that they could have moderately severe physical limitations or perhaps reduced cognitive abilities.

Each set of conditions was assigned to one of five categories capturing expected likelihoods of death or injury if the fire had involved a mattress that met the draft proposed standard; that a death (or injury) would still occur, would likely occur, would possibly occur, would be unlikely to occur, or would not occur. A range of probabilities was then assigned to each category to reflect those terms (See table below). For example, for each pre-standard death in the Possible (P) category, there would be between .45 to .55 deaths expected to occur if the involved mattress met the draft proposed standard.

[7] CPSC staff reviewers were Linda Smith, Directorate for Epidemiology, Allyson Tenney, Directorate for Engineering Sciences, and Carolyn Meiers, Directorate for Engineering Sciences.

Post-Standard Casualty Category	Probability of Post-Standard Occurrence
Y Death (or injury) would still occur	1
L Deaths (or injury) was considered likely to still occur.	.75 - .85
P Deaths (or injury) was considered possible to still occur.	.45 - .55
U Deaths (or injury) was considered unlikely to still occur.	.1 - .2
N No death (or injury) would occur	0

To estimate the higher number of expected deaths or injuries remaining, the higher probabilities in each category were applied. Conversely, the lower probabilities in each category were applied to calculate the lower number of expected deaths or injuries remaining. In the hypothetical example below, 5 deaths were present with one death occurring in each of the likelihood categories. For this subset, the expected number of deaths that would remain after the standard would range from 2.3 to 2.6.

Hypothetical Example
Children Younger Than Age 5 Dying in Open Flame Fires

Observation	Likelihood Category	Probability Range	Lower Probability of Still Occurring	Upper Probability of Still Occurring
1	Y	1	1	1
2	L	.75 - .85	.75	.85
3	P	.45 - .55	.45	.55
4	U	.1 - .2	.1	.2
5	N	0	0	0
Total: 5			**2.3**	**2.6**

The same categories and probability values were applied to both deaths and injuries. Unless a death was considered certain, the casualty also was assigned a likelihood category for injury. This took into account the possibility that if a person did not die he could still be injured. Whenever someone was injured trying to extinguish the fire, it was assumed that he/she would try to extinguish the fire under the new conditions as well. These persons were assigned to the "unlikely injury" category. The injury categories do not reflect estimates of the severity of remaining injuries. When location of the casualty was not specified, the arithmetic mean of the worst and best possibilities given the individual's circumstances was used to estimate the probability of death or injury.

Step 2) Estimate proportion of casualties prevented, by sub-category

Using unweighted investigation data, tables were constructed to estimate casualties prevented within each sub-category of interest (Appendix Tables D-3 for deaths and D-4 for injuries). The proportion of deaths (injuries) prevented by sub-category was estimated as follows:

$$P = (n^b - n^a)/n^b$$

where P= the estimated proportion of deaths (injuries) in the sub-category that would be prevented, n^b = number of deaths (injuries) in the sub-category in the investigation database, and n^a= estimated deaths (injuries) in the sub-category that would remain post-standard. In the hypothetical example above, the expected reduction for this hypothetical set would be calculated as

$$P = (5 - 2.3)/5 = .54, \text{ the greatest reduction, or}$$
$$P = (5\text{-}2.6)/5 = .48, \text{ the least reduction.}$$

Step 3) Estimate number of casualties prevented

Percentage reductions of deaths (injuries) within sub-categories of heat source and age group were applied to equivalent sub-categories of the national estimates based on the NFIRS and NFPA data for 1995 to 1999. In the hypothetical example above, setting the national estimate for this subset at a hypothetical 50 deaths, the estimate of deaths prevented among children younger than age 5 from open flame fires would be:

$$50 * .54 = 27 \text{ deaths, the greatest reduction, or}$$
$$50 * .48 = 24 \text{ deaths, the least reduction.}$$

Estimated reductions were summed for all subcategories to arrive at an overall estimate of deaths and injuries prevented. This was done in two steps, where all categories were set at the greatest reduction and where all categories were set at the least reduction.

Although NFIRS-level detail is not available at this time for post-1999 years, NFPA estimates of overall residential structure fires and fire losses are available through 2002 (Appendix Table D-5). Since NFPA estimates indicate that residential fires and fire losses have generally continued to decline, preliminary estimates of losses expected and prevented for the most recent 5-year period (1998 – 2002) were prepared. This estimation process required the following assumptions:

1) Mattress/bedding fires, total and addressable, as a proportion of all residential structure fires, have not changed from 1995 – 1999 to 1998 – 2002, and

2) Heat source and age group distributions involved in mattress/bedding fires have not changed from the early period to the later period.

Some conditions external to mattresses could reduce both smoking and open flame fires in years subsequent to 1999. Smoking rates have continued to decrease over the years.[8] Also, it

[8] The percentage of people over 18 who are cigarette smokers has declined from 25.3 percent in 1990 to 22.7 percent in 2001. *Health, United States, 2003*, National Health Interview Survey, National Center for Health Statistics.

is believed that the effects of the CPSC standard requiring child-resistant cigarette lighters, which took effect in July 1994, did not reach its full effect until 1998. Thus, the average involvement of lighter-caused fires could be smaller in 1998-2002 period than in the 1995-1999 period. The CPSC child–resistant multi-purpose lighter standard took effect in December 2000 but its effect may not be evident by 2002. If these factors have caused mattress/bedding casualties to decrease faster than other kinds of residential casualties, the estimates of addressable casualties presented here may be somewhat higher than estimates that may be developed later when more specific data become available.

III. Results

A. Fire Losses Addressable by the CPSC Staff's Draft Proposed Standard

Based on the methodology described in Section II, Table 1 presents average annual estimates of residential structure fires caused by ignition of mattresses and bedding for 1995 – 1999, the most recent years available that include product–level detail. There were an estimated 19,400 fires that resulted in 440 civilian deaths, 2,230 civilian injuries, and $273.9 million in direct property loss annually during this time period.

Table 1
Annual Estimated Fires and Fire Losses Involving Mattresses and Bedding, Attended by the Fire Service, 1995-1999

Heat Source	Fires	Deaths	Injuries	Property Loss in Millions
Total Mattress/Bedding	**19,400**	**440**	**2,230**	**$273.9**
Total Fire Losses Potentially Addressable	**18,500**	**440**	**2,160**	**$259.5**
Smoking Material – Potentially Addressable Smoking Material – Not Addressable	**5,800** *	**210** 0	**640** *	**$ 65.9** $ 0.6
Candles, Matches, Lighters – Potentially Addressable Candles, Matches, Lighters – Not Addressable	**6,000** 100	**100** 0	**980** 10	**$94.7** $1.4
Additional Small Open Flame – Potentially Addressable Additional Small Open Flame – Not Addressable	**800** *	**30** 0	**80** *	**$11.2** $0.3
Other In-Scope Ignition – Potentially Addressable Other In-Scope Ignition – Not Addressable	**5,900** 200	**90** 0	**470** 10	**$85.9** $2.7
Out-of-Scope Ignition Sources – Not Addressable	600	*	50	$9.4

All estimates rounded to nearest 100 fires, nearest 10 deaths or injuries, and nearest tenth of a million in property loss. Detail may not add due to rounding.
* Denotes rounded fire estimates of less than 100 and death or injury estimates of less than 10.

Source: U.S. Consumer Product Safety Commission, based on data from the U.S. Fire Administration and the National Fire Protection Association

In order to estimate the effect that the CPSC staff's draft proposed standard could have on mattress/bedding losses, the data were evaluated to identify fires and fire losses that were considered addressable, based solely on the characteristics of the fire cause. Deaths and injuries that occurred in these fires were considered potentially preventable by the draft proposed standard under consideration. These included most mattress/bedding fires and fire losses, regardless of heat source; 18,500 fires, 440 deaths, 2,160 injuries, and $259.5 million in property loss.

The staff's draft proposed standard is designed primarily to reduce the severity of mattress/bedding fires rather than prevent fires from occurring, although some fires also may be prevented. It is expected that property damage will be reduced as well, since the potential for flashover fires will be reduced, but it was not possible here to estimate what the size of that effect will be. Thus, the remainder of this report will be limited to discussion of addressable deaths and injuries.

Estimated addressable deaths and injuries in fires attended by the fire service, categorized by heat source, age group of the casualty, and location of the casualty at the time the fire started, are presented in Tables 2 and 3 respectively. Smoking fires accounted for 210 of the addressable deaths (48 percent), and 640 of the addressable injuries (30 percent). Of these, adults accounted for about 90 percent of the smoking deaths and injuries. Open flame fires accounted for about 140 of the addressable deaths (32 percent) and 1,050 of the addressable injuries (49 percent). Of these, children younger than age 15 accounted for 90 deaths (64 percent) and 340 injuries (32 percent).

By location of the casualty at the time of ignition, an estimated 20 percent of the deaths and 16 percent of the injuries in fires attended by the fire service involved people present at the point of ignition (Table 4). An estimated 32 percent of the deaths and 24 percent of the injuries involved people in the room of origin but not at the point of ignition. The remaining casualties were either outside the area of origin or at an unknown location.

Among the 2,160 addressable injuries in fires attended by the fire service (Table 5), an estimated 940 (43 percent) involved asphyxia alone, 560 injuries (26 percent) involved only burns, and 450 injuries (21 percent) involved both asphyxia and burns. An estimated 1,550 injuries (72 percent) were taken for emergency treatment. It is not known how many were hospitalized.

Table 2
Estimated Addressable Mattress/Bedding Fire Deaths
By Heat Source, Age Group & Location of Casualty at the Time of Ignition
1995 – 1999 Annual Average, Fire Service Attended

Age Group & Victim Location at Time of Ignition	Total	Heat Source		
		Smoking	Open Flame	Other
Total	440 (100%)	210 (48%)	140 (32%)	90 (20%)
Less Than Age 5	90 (20%)	10	60	10
At Point of Ignition	20	0	10	**
In Room of Origin- Not at Point of Ignition	30	**	20	10
Outside Room of Origin	40	10	30	**
Location Unknown	**	0	**	0
Ages 5 to 14	30 (7%)	**	30	10
At Point of Ignition	**	0	**	0
In Room of Origin-Not at Point of Ignition	10	0	10	**
Outside Room of Origin	20	**	10	**
Location Unknown	**	0	**	**
Ages 15 to 64	190 (43%)	130	30	30
At Point of Ignition	40	40	**	**
In Room of Origin-Not at Point of Ignition	60	30	10	10
Outside Room of Origin	80	50	20	10
Location Unknown	20	10	**	**
Ages 65+	120 (27%)	60	20	50
At Point of Ignition	30	20	10	**
In Room of Origin-Not at Point of Ignition	40	20	**	10
Outside Room of Origin	40	10	10	20
Location Unknown	20	10	**	**

** Estimate is less than 5.
Estimates rounded to nearest ten. Detail may not add due to rounding.
Source: U.S. Consumer Product Safety Commission, based on data from the U.S. Fire Administration and the National Fire Protection Association

Table 3
Estimated Addressable Mattress/Bedding Fire Injuries
By Heat Source, Age Group & Location of Casualty at the Time of Ignition
1995 – 1999 Annual Average, Fire Service Attended

Age Group & Victim Location at Time of Ignition	Total	Heat Source		
		Smoking	Open Flame	Other
Total	2,160 (100%)	640 (30%)	1,050 (49%)	470 (21%)
Less Than Age 5	240 (11%)	30	160	40
At Point of Ignition	40	**	40	**
In Room of Origin-Not at Point of Ignition	50	10	30	10
Outside Room of Origin	70	10	40	20
Location Unknown	80	20	50	10
Ages 5 to 14	260 (12%)	20	180	50
At Point of Ignition	70	**	50	10
In Room of Origin-Not at Point of Ignition	60	**	50	10
Outside Room of Origin	80	10	50	20
Location Unknown	40	10	30	**
Ages 15 to 64	1,420 (66%)	470	640	310
At Point of Ignition	190	120	40	30
In Room of Origin-Not at Point of Ignition	350	120	140	90
Outside Room of Origin	660	150	360	150
Location Unknown	220	70	100	40
Ages 65+	250 (12%)	120	70	60
At Point of Ignition	40	30	10	10
In Room of Origin-Not at Point of Ignition	50	20	10	20
Outside Room of Origin	100	40	30	30
Location Unknown	50	30	10	10

** Estimate is less than 5.
Estimates rounded to nearest ten. Detail does not add due to rounding.
Source: U.S. Consumer Product Safety Commission, based on data from the U.S. Fire Administration and the National Fire Protection Association

Table 4
Estimated Addressable Casualties, by Location at Time of Ignition
1995 – 1999 Annual Average, Fire Service Attended

Location of Casualty at Time of Ignition	Estimated Casualties	
	Deaths	Injuries
Total	440 (100%)	2,160 (100%)
At Point of Ignition	90 (20%)	340 (16%)
In Room of Origin-Not at Point of Ignition	140 (32%)	510 (24%)
Outside Room of Origin	180 (41%)	910 (42%)
Location Unknown	30 (7%)	390 (18%)

Note: detail does not add due to rounding.
Source: U.S. Consumer Product Safety Commission, based on data from the U.S. Fire Administration and the National Fire Protection Association

Table 5
Estimated Addressable Injuries, by Diagnosis
1995 – 1999 Annual Average, Fire Service Attended

Diagnosis	Estimate	Percent
Total	2,160	100
Asphyxia Only	940	43
Burns Only	560	26
Asphyxia and Burns	450	21
Other	200	9

Note: Detail does not add due to rounding
Source: U.S. Consumer Product Safety Commission, based on data from the U.S. Fire Administration and the National Fire Protection Association

B. Casualties That Could be Prevented by the CPSC Staff's Draft Proposed Standard

Based on a Post-Standard Casualty Category Criteria guideline (Appendix C, Tables C-1 and C-2), CPSC staff assessed the likelihood that each occupant cited in an investigated fire who died or was injured (1999 – 2003) would still die or be injured if the mattress met the staff's draft proposed standard that requires a testing time of 30 minutes. Percentage reductions were calculated by sub-categories, using the pre-standard deaths and injuries reported in the investigations and the anticipated post-standard deaths and injuries that would remain. When adequate data were available, these percentages were then applied to the national estimates of addressable deaths and injuries in the equivalent sub-categories, and summed, to arrive at overall estimates of the number and percentages of deaths and injuries that could be prevented annually for 1995 – 1999.

1. Casualties Prevented, by Location at the Time of the Fire

The location of the victim at the time the fire began was one of the factors used to evaluate the likelihood that a post-standard death or injury would remain. Since several sub-categories of the investigation data did not include casualties, it was not feasible to evaluate percentage reductions by location in combination with other variables. Table 6, not adjusted to national estimates, presents percentage reductions by casualty location when location was reported in the investigation.[9] These data indicate that a larger proportion of deaths are prevented as the casualty's location gets further away from the point of ignition, rising to 99 percent when the casualty is outside the area of origin.

Injuries did not follow the same pattern, largely due to occupants who entered the room of origin to fight the fire (Table 6). The evaluation process assigned a low probability of expected injury to any occupant who was injured fighting the fire since it was assumed that this behavior would continue under the new circumstances.

Table 6
Range of Percentage Reduction of Casualties,
by Location of the Casualty at the Time of Ignition
Fire Service Attended

Location of Casualty at Time of Ignition	Percent Reduction	
	Deaths	Injuries
At the Point of Ignition	66% - 75%	75% - 85%
In the Room of Origin, but Not at Point of Ignition	87% - 93%	89% - 94%
Outside the Room of Origin	99%	93% - 97%

Note: Includes deaths and injuries only in fires attended by the fire service.
Table excludes casualties for whom location at ignition was not known.
Source: CPSC Investigation Reports, 1/ 99 – 6/04.
U.S. Consumer Product Safety Commission

2. 1995 – 1999 Estimated Casualties That Could Be Prevented

Applying the anticipated percentage reductions in post-standard casualties (Tables D-3 and D-4) to estimates of pre-standard addressable casualties (Tables 2 and 3), CPSC staff estimates that 350 to 370 mattress/bedding deaths annually (80 to 86 percent overall reduction) could have been prevented in 1995 – 1999 (Table 7). By age group, the estimated reduction among children younger than age 5 was 70 to 80 deaths annually (85 – 92 percent), among ages 5 to 14 the reduction was 30 deaths annually (94 to 97 percent), among ages 15 – 64 the

[9] Since these data have not been weighted to the national estimates, it is possible that the results in Table 6 could have been somewhat different if the effect of location varied by heat source.

reduction was 140 to 150 deaths annually (74 to 80 percent), and among adults age 65 and older the reduction was 90 deaths annually (69 to 75 percent). By heat source type, the reductions were 74 to 80 percent for smoking ignitions, 83 to 89 percent for open flame ignitions, and 81 to 87 percent for other addressable ignitions.

For injuries during this time period (Table 8), the range of injuries prevented was an estimated 1,850 to 1,980 annually (86 to 92 percent overall reduction). By age group, the estimated reduction among children younger than age 5 was 190 to 200 injuries annually (80 to 87 percent), among children ages 5 to 14 the reduction was 220 to 240 injuries annually (88 to 94 percent), among those ages 15 to 64 the reduction was 1,240 to 1,320 injuries annually (87 to 93 percent), and among adults ages 65 and older the reduction was 220 to 230 injuries annually (87 to 91 percent). By heat source, an estimated 87 to 92 percent of smoking ignition injuries could be prevented, along with 86 to 92 percent of open flame injuries, and 85 to 92 percent of other addressable injuries.

Table 7
Estimated Mattress/Bedding Fire Deaths Prevented by the Standard
By Age Group and Heat Source
1995 -1999 Annual Average, Fire Service Attended

Heat Source	Total	Age Group (years)			
		Less Than 5	5 to 14	15 to 64	65+
Total					
1995 - 1999 Estimate	**440**	**90**	**30**	**190**	**120**
Percent to be Reduced	**80 - 86**	**85 - 92**	**94 - 97**	**74 - 80**	**69 - 75**
Number Prevented	**350 - 370**	**70 - 80**	**30**	**140 - 150**	**90**
Smoking					
1995 - 1999 Estimate	210	10	**	130	60
Percent to be Reduced	74 - 80	100	100	72 - 79	68 - 76
Number Prevented	150 - 160	10	**	100	40 -50
Open Flame					
1995 - 1999 Estimate	140	60	30	30	20
Percent to be Reduced	83 - 89	83 - 90	94 - 97	80 - 85	62 - 66
Number Prevented	120	50 - 60	20 - 30	30	10
Other					
1995 - 1999 Estimate	90	10	10	30	40
Percent to be Reduced	81 - 87	87 - 94	91 - 96	68 - 74	74 - 79
Number Prevented	70 - 80	10	10	20	30 - 40

** Estimate is less than 5.
Detail may not compute due to rounding of estimates presented. All calculations based on unrounded data.
U.S. Consumer Product Safety Commission

Table 8
Estimated Mattress/Bedding Fire Injuries Prevented by the Standard
By Age Group and Heat Source
1995 -1999 Annual Average, Fire Service Attended

Heat Source	Total	Age Group (Years)			
		Less Than 5	5 to 14	15 to 64	65+
Total					
1995 - 1999 Estimate	**2,160**	**240**	**260**	**1,420**	**250**
Percent to be Prevented	**86 - 92**	**80 - 87**	**88 - 94**	**87 - 93**	**87 - 91**
Number Prevented	**1,850 – 1,980**	**190 - 200**	**220 - 240**	**1,240 – 1,320**	**220 - 230**
Smoking					
1995 - 1999 Estimate	640	30	20	470	120
Percent to be Prevented	87 - 92	90 - 95	100	86 - 91	84 - 92
Number Prevented	560 - 590	30	20	400 - 420	100 – 110
Open Flame					
1995 - 1999 Estimate	1,050	160	180	640	60
Percent to be Reduced	86 - 92	80 - 87	86 - 92	89 - 94	82 - 88
Number Prevented	920 - 970	140	160 - 170	570 - 600	50 - 60
Other					
1995 - 1999 Estimate	470	40	50	310	60
Percent to be Reduced	85 - 92	76 - 82	89 - 94	85 - 92	85 - 93
Number Prevented	390 - 430	30 – 40	40 - 50	260 - 280	50 - 60

Detail may not compute due to rounding of estimates presented. All calculations based on unrounded data.
U.S. Consumer Product Safety Commission

2. 1998 – 2002 Estimated Casualties Prevented

National estimates of fire cause and casualty detail are available only through NFIRS, for which the most recent year available is 1999. However, the NFPA estimates to which NFIRS data are applied are available through 2002 (Appendix Table D-5). If we assume that addressable mattress/bedding fire deaths and injuries account for the same percentage of residential casualties in 1998 – 2002 as in 1995 - 1999 (12.6 percent of all residential fire deaths and 12.0 percent of all residential fire injuries), we are able to estimate more recent mattress/bedding fire losses prevented. This also assumes that the distribution of ignition type among mattress fires remains the same. Applying the estimated overall percentage reductions discussed in the previous section to the more recent NFPA estimates, we estimate that 310 to 330 deaths and 1,660 to 1,780 injuries in fires attended by the fire service could have been prevented annually during the time period 1998 to 2002 (Table 9).

Table 9
Estimated Residential Mattress/Bedding
Fire Deaths and Injuries That Could be Prevented
1998 – 2002 Annual Average

	Annual Deaths	Annual Injuries
Estimated Addressable Mattress/Bedding Casualties [1]	390	1,940
Range of Percentages Prevented [2]	80 - 86	86 - 92
Range of Estimated Casualties Prevented	310 - 330	1,660 – 1,780

[1] Assumes addressable deaths = 12.6 % and addressable injuries = 12.0 % of all residential structure fire casualties, based on NFIRS and NFPA
[2] From Tables D-3 and D-4, CPSC investigations
U.S. Consumer Product Safety Commission

Deaths and injuries that could be prevented by a standard requiring a 60 minute test period were not specifically calculated. However, the maximum additional losses that could be prevented would be 80 deaths and 280 injuries per year, the difference between the total deaths and injuries considered addressable and those expected to be reduced by a standard with a 30 minute test period. The likely reductions, however, could be much lower. In view of the characteristics of those considered likely to die or be injured in conditions associated with a proposed 30 minute test, e.g., those incapable of acting on their own and with no potential rescuer in the occupancy, the chances of their rescue in a longer time remain unpredictable.

IV. Discussion

A major challenge in evaluating the effectiveness of the staff's draft proposed standard was predicting how the current casualties, with varied personal characteristics and in varied circumstances, would have fared under the less severe fire conditions expected with the draft proposed standard. CPSC staff was unable to locate any time-based data on evacuation from residential occupancies. Moreover, most fire databases capture details only about the casualty, providing little if any information about other members of the household who were present, unless they too were injured.

Following initial review of CPSC investigations of mattress/bedding fires to identify critical features, CPSC staff developed a set of criteria that were used to predict likelihood of death or injury for each casualty. The general terms of "likely," "possible," and "unlikely," plus those thought to be definitely remaining or definitely prevented, were thought to represent the most specific level of certainty that could be predicted. To translate those terms to the number of people who would die or be injured, a range of probabilities was assigned to each term to capture the staff's expectation for that category.

CPSC in-depth investigations of mattress and bedding fires provided a wealth of detail not found in automated databases. Investigation reports included information about the characteristics of the fire, where people were in relation to the fire, and how people reacted as individuals and as interactive family members. CPSC investigations also documented the often crucial role of family members.

The presence of a rescuer in the household was considered especially important when children or others who had severe physical restrictions were present.[10] For example, the investigations provided information about how children reacted, lending insight as to why some children died or were injured while others, apparently in the same situation, escaped safely. Some children ages 5 to 9 broke away from the rest of the family who were exiting the house and ran to other rooms. By the time the adults were able to return to the house, the fire was too severe to proceed. In such cases, it was felt that the expected ten to fifteen minutes of time would have been enough to locate the child and allow rescue. It should be noted that lack of a rescuer was sometimes mitigated by the ability of even some children younger than age 5 to exit on their own, e.g., to reach neighbors.

Other situations of particular concern were occupants who were asleep at the point of ignition, usually adults who fell asleep while smoking in bed. While it is uncertain how long it might have taken a sleeping person to awaken, there was evidence that many of those who died had awakened and attempted escape since they were found on the floor rather than on the bed. Since they were able to attempt escape given the current rapid progression of mattress fires (less than five minutes to achieve conditions too hot to breathe), the greater length of time available was expected to allow most people who were not severely handicapped to escape. If the person was found still on the bed, it was usually when other conditions such as alcohol were present and it was not clear to what extent additional time would have helped them.

The special vulnerability of people over age 85 also was taken into account since they are not, in general, as able to recover from severe injuries as easily as younger people. The fire death rate among people age 85 and older is more than four times that of the general population.[11] Similarly, people who lived alone seemed to be at special risk since no rescuers were immediately present. Even so, in some cases, neighbors noticed smoke or flames from the occupancy and both called the fire department and attempted rescue. (For the purposes of this analysis, people were considered potential rescuers only if they were in the same household.)

Most fires that involved mattresses involved bedding as well, and the role of bedding as a contributor to both ignition and fuel load is of concern. The type and number of bedclothes present in any given fire was quite variable and the uncertainty regarding their contribution to the fire added to the complexity of assessing risk reduction. The involvement of bedding is discussed further in a separate report (Tab EP)

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[10] When only children were present, only a child over 14 was considered a potential rescuer. This was based on guidance for the appropriate ages for babysitters that is used by several local jurisdictions.

[11] Hall, John R., Jr. Patterns of Fire Casualties in Home Fires by Age and Sex, National Fire Protection Association, Quincy, MA , August 2001.

In view of the time lag of the NFIRS data, it is difficult to estimate the age distributions of the casualties that are occurring in more recent years. As discussed earlier, it is believed that most of the major reductions in deaths resulting from the cigarette lighter standard were not substantially in place until 1998, so that the 1995 – 1999 averages may be higher than in more recent years. Effects of the multi-purpose lighter standard, expected to be smaller than reductions due to cigarette lighters, may not be fully in place until 2004. Further reductions in smoking may be expected in future years but the reduction in percentage of the U.S. population that smokes has been less than one percent annually in recent years. In summary, it is likely that the age distribution of recent casualties and the ignition types involved could be somewhat different than the distributions estimated from the earlier data.

Available data in both attended and not attended fires indicate that some people attempt to extinguish the fire. If mattress and bedding fires become less severe on average, it may be that a larger proportion of occupants will attempt to extinguish them. Since their success and likelihood of being injured will also depend on the nature of the fire, it is not clear what the net effect on non-fatal injuries will be, although it is clear that many fewer people will die.

V. Conclusion

Based on the most recent available data, an estimated 310 to 330 deaths and 1,660 to 1,780 injuries resulting from mattress and bedding fires may be prevented annually as a result of the CPSC staff's draft proposed standard. Since the potential for flashover fires is expected to be reduced as well, a large part of the annual property loss also may be prevented.

For children, the relatively high proportion of casualties that could be prevented is a result of the increased time that would be available for other residents to return for rescue. Currently, anyone who didn't exit immediately could not be rescued later. Adults at the point of ignition would benefit primarily from the increased time during which air in the room would continue to be breathable. Except in rare circumstances, everyone who was outside the room of origin when the fire ignited would be expected to survive, though some would be injured if they returned to fight the fire.

Table A-1
Standard Codes Used in Mattress and Bedding Fire Loss Estimates

Form of Heat of Ignition(Heat Source)	NFPA 901 Standard Codes
Smoking Materials	Cigarettes (31) Cigars (32) Pipes (33) Unknown smoking materials (30, 39)
Traditional Small Open Flame Sources	Candles (44) Matches (45) Lighters (46)
Additional Small Open Flame Sources	Spark, ember, flame escaping from gas fueled equipment (11) Spark, ember, flame escaping from liquid fueled equipment (13) Spark, ember, flame escaping from solid fueled equipment (15) Spark, ember, flame escaping from equipment, fuel not known (17) Arc, spark from operating equipment or switch (26) Torch operation, other than cutting and welding. Included are plumbers' furnaces, blow torches, plumbers' torches, Bunsen burners, soldering and heating operations, paint stripping torches, and other torch operations. (43) Hot ember, ash. (53) Fireworks. Included are sparklers. (63) Paper cap, party popper (64)
Other In-scope Heat Sources	Heat from gas fueled equipment (12) Heat from liquid fueled equipment (14) Heat from solid fueled equipment (16) Heat from equipment: fuel not known (18) Heat from Fuel-Fired, Fuel-Powered Object not classified above (19) Water caused short circuit arc (21) Short circuit arc from mechanical damage (22) Short circuit arc from defective, worn insulation (23) Unspecified short circuit arc (24) Arc from faulty contact, loose connection, broken conductor (25) Heat from overloaded equipment. Included are wires and motors. (27) Heat from Electrical Equipment Arcing, Overloaded not classified above (29) Cutting torch operation (separating metals) (41)

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	Welding torch operation (joining metals) (42) Open fire. Included are campfires, bonfires, warning flares, rubbish fires, open trash burners, open incinerators, and outdoor fireplaces. (47) Heat from Open Flame, Spark not classified above (49)Heat, spark friction. Included are overheated tires. (51) Molten, hot material. Included are molten metal, hot forging, and hot glass. (52) Electric lamp. Included are light bulbs. (54)Heat from properly operating electrical equipment (56) Heat from Hot Object not classified (59)Model rocket, not amateur rocketry (65) Sun's heat. Usually magnified through broken glass or glass bottle. (71) Spontaneous ignition, chemical reaction. (72) Static discharge (74) Heat from Natural Source not classified above(79) Other Form of Heat of Ignition not classified above (99)
Out-of-Scope Heat Sources	Rekindle, reignition (55) Explosive (61) Blasting agent (62) Incendiary device. Included are Molotov cocktails. (66) Heat from Explosive, Fireworks not classified above (69) Lightening discharge (73) Heat Spreading from Another Hostile Fire (80-89) Multiple forms of Heat of Ignition. Use this code only where there are multiple fires started at approximately the same time on the same property and more than one heat of ignition was initially involved. (97)
Unknown Heat Sources	00, missing codes, and blanks
Form of Material First Ignited	
Mattress, pillow	31
Bedding, blanket, sheet, comforter	32
Other soft goods	33 – 39 (second stage raking only)
Not Mattress/Bedding	All codes except 31, 32, and unknown form of material ignited
Unknown Form of Material Ignited	00, missing codes, and blanks, 30 (Unknown Soft Goods)

Table A-2.1
Mattress and Bedding Fire Loss Editing Procedure
Traditional Small Open Flame (Candles, Matches, Lighters) and Smoking Material Heat Sources

Variable	Mattress/Bedding – Addressable (In-scope)	Mattress/Bedding – Not Addressable (Out-of-scope)	Not Mattress/Bedding
Type of Material First Ignited	Plastic (40- 49) Natural Product, insufficient information to classify further (50) Rubber (51) Leather (53) Grain, natural fiber (pre- process) (55) Included are feathers, felt, kapok, hessian, hemp, sisal, jute, cocofilm, flax, and cotton. Natural Product not classified above (59) Wood, Paper; insufficient information to classify further (60) Sawn wood. Included are all finished lumber (63) Hardboard, plywood (65) Fiberboard (low density ,material), wood pulp. Included are low density pressed wood fiber board products. (66) Paper, untreated, uncoated. Excluded are waxed papers. (67) Cardboard (68) Wood, Paper not classified above (69)		Gas (10-19) Flammable, Combustible Liquid (20-29) Volatile Solid, Chemical (30-39) Cork (52) Grass, leaves, hay, straw (54) Coal, coke, briquettes, peat (56) Food, starch. Included are fat and grease. (57) Tobacco (58) Growing wood (61) Felled but unsawn wood (62) Wood shavings. Included are sawdust and excelsior. (64) Wig (75) Human hair (76) Material Compounded with Oil (80-82,85-89) Multiple types of material first ignited. Use only where there are multiple fires started at approximately the same time on the same property and more than one type of material was involved. (97) Type of material not applicable (98)

	Fabric, Textile, Fur (70- 74, 77- 79) Man- made fabric, fiber, finished goods (71) Cotton, rayon, cotton fabric, finished goods (72) Wool, wool mixture fabric, finished goods (73) Fur, silk, other fabric, finished goods (74) Unknown type of fabric, textile, fur (70,79) Treated and/or coated paper. Included is waxed paper. (83) Waterproof canvas. Excluded is waterproof cloth of rayon covered with neoprene . (84) Type of Material not classified above (99) Missing data codes (00, ??, blanks)		
Area of Origin	Means of Egress (01- 03, 05- 09) Assembly, Sales Areas (11- 19) Function Areas (21 – 39) Storage Areas (41 – 49) Service Areas (51, 56- 59) Service, Equipment Areas (60- 69) Structural Areas (71-77, 79) Other Area of Origin (91- 99) Missing data codes (00, ??, blanks)		Escalator (04) Utility shaft (52) Light shaft (53) Chute (54) Duct (55) Chimney (57) Conveyer (58) Awning (78) Transportation, Vehicle Areas (80- 89)
Ignition Factor	Misuse of Heat of Ignition (30- 34, 36- 39) Misuse of Material Ignited (40, 45-49) Mechanical Failure, Malfunction (50- 53, 56, 59) Design, Construction, Installation	Cutting, welding too close (35) Fuel spilled, released accidentally (41) Improper fueling technique (42) Flammable liquid used to kindle fire (43)	

	Deficiency (60-64, 69) Operational Deficiency (70-73, 75-79) Other Ignition Factor (90- 91, 99) Missing data codes (00, ??, blanks)	Washing part, cleaning, refinishing, painting (44) Short circuit, ground fault (54) Other electrical failure (55) Backfire. Included are ignitions outside the combustion chamber. Excluded are fires originating as a result of hot catalytic converters. (57) Property too close to. Included are exposure fires. (65) Overloaded (74) Natural Condition (80- 89) Rekindle from a previous fire (92)	
Equipment Involved in Ignition	Other object, insufficient information to classify further (90) No equipment involved (98) Other object not classified above (99) Missing data codes (00, ??, blanks).	All other codes	

Table A-2.2
Mattress and Bedding Fire Loss Editing Procedure
Additional Small Open Flame Sources and Other In-scope Heat Sources

Variable	Mattress/Bedding – Addressable (In-scope)	Mattress/Bedding – Not Addressable (Out-of-scope)	Not Mattress/Bedding
Type of Material First Ignited	Plastic (40- 49) Natural Product, insufficient information to classify further (50) Rubber (51) Leather (53) Grain, natural fiber (pre- process) (55) Included are feathers, felt, kapok, hessian, hemp, sisal, jute, cocofilm, flax, and cotton. Natural Product not classified above (59) Wood, Paper; insufficient information to classify further (60) Sawn wood. Included are all finished lumber (63) Hardboard, plywood (65) Fiberboard (low density ,material), wood pulp. Included are low density pressed wood fiber board products. (66) Paper, untreated, uncoated. Excluded are waxed papers. (67) Cardboard (68) Wood, Paper not classified above (69) Fabric, Textile, Fur (70- 74, 77- 79) Man- made fabric, fiber, finished goods (71) Cotton, rayon, cotton fabric, finished goods (72)		Gas (10-19) Flammable, Combustible Liquid (20-29) Volatile Solid, Chemical (30-39) Cork (52) Grass, leaves, hay, straw (54) Coal, coke, briquettes, peat (56) Food, starch. Included are fat and grease. (57) Tobacco (58) Growing wood (61) Felled but unsawn wood (62) Wood shavings. Included are sawdust and excelsior. (64) Wig (75) Human hair (76) Material Compounded with Oil (80-82,85-89) Multiple types of material first ignited. Use only where there are multiple fires started at approximately the same time on the same property and more than one type of material was involved. (97) Type of material not applicable (98)

	Wool, wool mixture fabric, finished goods (73) Fur, silk, other fabric, finished goods (74) Unknown type of fabric, textile, fur (70,79) Treated and/or coated paper. Included is waxed paper. (83) Waterproof canvas. Excluded is waterproof cloth of rayon covered with neoprene . (84) Type of Material not classified above (99) Missing data codes (00, ??, blanks)		
Area of Origin	Means of Egress (01- 03, 05- 09) Assembly, Sales Areas (11- 19) Function Areas (21 – 39) Storage Areas (41 – 49) Service Areas (51, 56- 59) Service, Equipment Areas (60- 69) Structural Areas (71-77, 79) Other Area of Origin (91- 99) Missing data codes (00, ??, blanks)		Escalator (04) Utility shaft (52) Light shaft (53) Chute (54) Duct (55) Chimney (57) Conveyer (58) Awning (78) Transportation, Vehicle Areas (80- 89)
Ignition Factor	Misuse of Heat of Ignition (30-39) Misuse of Material Ignited (40, 45-49) Mechanical Failure, Malfunction (50-59) Design, Construction, Installation Deficiency (60-64, 69) Operational Deficiency (70-79) Other Ignition Factor (90- 91, 99) Missing data codes (00, ??, blanks)	Fuel spilled, released accidentally (41) Improper fueling technique (42) Flammable liquid used to kindle fire (43) Washing part, cleaning, refinishing, painting (44) Property too close to. Included are exposure fires. (65) Natural Condition (80- 89) Rekindle from a previous fire (92)	

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Equipment Involved in Ignition	Heating Systems (10-19) Cooking Equipment (20-29) Air Conditioning, Refrigeration Equipment (30-39) Electrical Distribution Equipment (40-49) Appliances, Equipment (50-59) Special Equipment (60-69) Torches. Included are cutting, welding, and plumbers torches, Bunsen burners, and the like. (87) Other object, insufficient information to classify further (90) No equipment involved (98) Other object not classified above (99) Missing data codes (00, ??, blanks).	Processing Equipment (70-79) Service, Maintenance Equipment (80-86, 89) Other Object, Exposure Fire (91-96)	

Table A-2.3
Mattress and Bedding Fire Loss Editing Procedure
Out-of-Scope Heat Sources

Variable	Mattress/Bedding – Addressable (In-scope)	Mattress/Bedding – Not Addressable (Out-of-scope)	Not Mattress/Bedding
Type of Material First Ignited		Plastic (40- 49) Natural Product, insufficient information to classify further (50) Rubber (51) Leather (53) Grain, natural fiber (pre- process) (55) Included are feathers, felt, kapok, hessian, hemp, sisal, jute, cocofilm, flax, and cotton. Natural Product not classified above (59) Wood, Paper; insufficient information to classify further (60) Sawn wood. Included are all finished lumber (63) Hardboard, plywood (65) Fiberboard (low density ,material), wood pulp. Included are low density pressed wood fiber board products. (66) Paper, untreated, uncoated. Excluded are waxed papers. (67) Cardboard (68) Wood, Paper not classified above (69) Fabric, Textile, Fur (70- 74, 77- 79) Man- made fabric, fiber, finished goods (71) Cotton, rayon, cotton fabric, finished goods (72)	Gas (10-19) Flammable, Combustible Liquid (20-29) Volatile Solid, Chemical (30-39) Cork (52) Grass, leaves, hay, straw (54) Coal, coke, briquettes, peat (56) Food, starch. Included are fat and grease. (57) Tobacco (58) Growing wood (61) Felled but unsawn wood (62) Wood shavings. Included are sawdust and excelsior. (64) Wig (75) Human hair (76) Material Compounded with Oil (80-82,85-89) Multiple types of material first ignited. Use only where there are multiple fires started at approximately the same time on the same property and more than one type of material was involved. (97) Type of material not applicable (98)

		Wool, wool mixture fabric, finished goods (73) Fur, silk, other fabric, finished goods (74) Unknown type of fabric, textile, fur (70,79) Treated and/or coated paper. Included is waxed paper. (83) Waterproof canvas. Excluded is waterproof cloth of rayon covered with neoprene . (84) Type of Material not classified above (99) Missing data codes (00, ??, blanks)	
Area of Origin		Means of Egress (01- 03, 05- 09) Assembly, Sales Areas (11- 19) Function Areas (21 – 39) Storage Areas (41 – 49) Service Areas (51, 56- 59) Service, Equipment Areas (60- 69) Structural Areas (71-77, 79) Other Area of Origin (91- 99) Missing data codes (00, ??, blanks)	Escalator (04) Utility shaft (52) Light shaft (53) Chute (54) Duct (55) Chimney (57) Conveyer (58) Awning (78) Transportation, Vehicle Areas (80- 89)
Ignition Factor		All codes	
Equipment Involved in Ignition		All codes	

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Appendix B
Allocation of Unknown Values

A technique known as raking was used to allocate the unknown values for each of the variables used for this analysis. Raking involves an iterative mathematical procedure to adjust a cross-tabulation of the data so that the resulting table, without unknowns, maintains the same proportional relationship as the original cross-tabulation. Battaglia, Hoaglin, and Izrael describe the raking algorithm and provide the statistical software (SAS version 6.12; SAS Institute, Inc., Cary, NC).[12]

For years 1995 – 1998 two stages of raking were done. The first stage allocated incidents in which no information was known for a variable (e.g, no indication of heat source was cited). The variables that were raked in this first stage were Ignition Factor, Form of Heat of Ignition (Heat Source), Form of Material First Ignited (Item Ignited), and Casualty Age. Area of Origin, Type of Material Ignited, Equipment Involved in Ignition, and Location of Victim were carried through the raking process but no unknowns were allocated. Area of Origin, Type of Material Ignited, and Equipment Involved in Ignition variables were used only to edit out cases and were not used further in the analysis. Unknowns for the Location of Victim variable were retained as 'Undetermined' location, which was a final category for that variable, so no allocation was done for this variable.

The second stage of raking involved allocation of incidents for which partial information was known (e.g., the heat source was known to involve an open flame but not whether the open flame was a match, lighter, etc.). In the version of the NFIRS codes used in 1995-1998, variables had partial as well as complete unknowns. The complete unknowns were raked in the first stage. Partial unknowns were raked in the second stage. Some partial unknowns for the variables Form of Material First Ignited and Form of Heat of Ignition were raked. Cases coded as '30 – Soft Goods, Wearing Apparel; insufficient information available to classify further' were raked among all the 30s series (Soft Goods, Wearing Apparel). Remember that 31 and 32 are the codes for mattresses and bedding respectively, so some of these cases were allocated as mattress and bedding fires.

Partial Unknown	Items it is Raked Into
30 – Soft Goods, Wearing Apparel; insufficient information to classify further	31 - Mattress 32 - Bedding 33 – 39 – Various non-mattress and bedding soft goods and wearing apparel

The Form of Heat (Heat Source) variable was used to determine whether a mattress or bedding fire was ignited by smoking materials, a small open flame, another in-scope heat source, or an out-of- scope heat source. It also, as described above, affected whether a case was considered addressable by the staff's draft proposed standard. Partial unknowns

[12] M. Battaglia, D. Hoaglin and D. Izrael, "A SAS Macro for Balancing a Weighted Sample", SAS Users Group International (SUGI) 25th Annual Conference, April 9 -12, 2000, Paper #258-25.

were raked into their respective series. An example is '40 – Heat from Open Flame, Spark; insufficient information available to classify further'. This was allocated among the 40s series, which is 'Heat from Open Flame, Spark':

Partial Unknown	Items it is Raked Into	Heat Source
40 – Heat from Open Flame, Spark; insufficient information to classify further	41 – Cutting Torch Operation	Other In Scope
	42 – Welding Torch Operation	Other In Scope
	43 – Torch Operation, other	Other In Scope
	44 – Candle	Small Open Flame
	45 – Match	Small Open Flame
	46 – Lighter	Small Open Flame
	47 – Open Fire, included are campfires, bonfires, etc.	Out of Scope
	48 – Backfire from internal combustion engine	Other In Scope
	49 – Heat from Open Flame, Spark; not classified above	Other In Scope

All of the variables that passed through the first stage of raking passed through the second, but only Type of Material First Ignited and Form of Heat (Heat Source) have partial unknowns to be raked. After the second stage of raking, the intentional cases were eliminated based on the Ignition Factor variable. It was also after the second stage of raking that Area of Origin, Equipment Involved in Ignition, Type of Material First Ignited, and Form of Heat (Heat Source) were used to determine which cases were edited out and which cases were labeled as not addressable. In other words, the editing and elimination of intentional cases occurred after raking.

The raking procedure in 1999 was simpler than in previous years because of the revisions to the NFIRS coding system. The new NFIRS coding system has no partial unknowns. There is no equivalent code for the Form of Material First Ignited code '30 – Soft Goods, Wearing Apparel; insufficient information available to classify further'. Cases that would have been coded this way in previous years are coded as 'Undetermined Item Ignited' (a complete unknown) in the new system. Therefore these cases were raked in the first and only stage of raking for 1999 estimation. The same was true for Form of Heat of Ignition which is called Heat Source in 1999. As with estimates for years 1995 – 1998, editing and elimination of intentional fires occurred after raking for 1999 estimates.

Appendix C

Table C-1
Post-Standard Casualty Category Criteria
Current Deaths

Situation	Likelihood of Death	Likelihood of Injury
Intimate with Ignition		
Unable to Act (takes precedence)		
Restrained or Severe Physical Disablement (incapable of exiting alone)		
No rescuer available	L	U
Rescuer available	U	L
Ages 0-2		
No rescuer available	L	U
Rescuer available	U	P
Ages 3-4		
No rescuer available	P	P
Rescuer available	U	P
Asleep		
No indication of movement (found in bed) , any age	Y	
Indication of movement (found partially or fully off the bed)		
≥ Age 85 (assumes burned by bedclothes)	P	P
Ages <5 Same as above categories		
Ages 5-9		
No rescuer available	P	U
Rescuer available	U	U
Other Ages		
With Limiting Conditions (inc drugs, alcohol, mental incapacitation)	P	P
Without Limiting Conditions	U	U
Not Asleep		
Ages < 5 Same as above		
≥ Age 85		
With Limiting Conditions	U	P
Without Limiting Conditions	U	P
Ages 5-9		
No rescuer available	U	U
Rescuer available	U	U
Other Ages		
With Limiting Conditions	U	P
Without Limiting conditions	N	U

Legend: Likelihood of a Casualty Occurring
Y= Death Certain (1)
L= Likely (.75 - .85)
P=Possible (.45 - .55)
U=Unlikely (.1 - .2)
N=None (0)

Table C-1 (continued)
Current Deaths

In Room of Origin, Not Intimate with Ignition		
Unable to Act (takes precedence)		
Restrained or Severe Physical Disablement		
No rescuer available	L	U
Rescuer available	U	P
Ages 0-2		
No rescuer available	L	U
Rescuer available	U	P
Ages 3-4		
No rescuer available	U	U
Rescuer available	U	U
Asleep		
No indication of movement, any age	P	P
Indication of movement (partially or fully off the bed)		
≥ Age 85	U	U
Ages <5 Same as above		
Ages 5-9		
No rescuer available	U	U
Rescuer available	N	U
Other Ages		
With Limiting Conditions (inc drugs, alcohol, mental incapacity)	U	U
Without Limiting Conditions	N	U
Not Asleep		
Ages < 5. Same as above		
≥ Age 85		
With Limiting Conditions	U	L
Without Limiting Conditions	N	U
Ages 5-9		
No rescuer available	U	U
Rescuer available	N	N
Other Ages		
With Limiting Conditions	U	U
Without Limiting Conditions	N	N
Not in Room of Origin		
Physically Restrained, Severe Physical Disablement,		
Including ≤ age 2 with no rescuer	U	U
Other		
Not Entered Room	N	N
Entered Room of Origin Before Extinguishment	N	U
Fighting Fire, Regardless of Initial Location, Condition	N	U

Legend: Likelihood of a Casualty Occurring
Y= Death Certain(1)
L= Likely (.75 - .85)
P=Possible (.45 - .55)
U=Unlikely (.1 - .2)
N=None (0)
Source: U.S. Consumer Product Safety Commission

Table C-2
Post-Standard Casualty Category Criteria
Current Injuries

Situation	Likelihood of Injury
Intimate with Ignition	
Unable to Act (takes precedence)	
Restrained or Severe Physical Disablement (incapable of exiting alone)	
No rescuer available	Y
Rescuer available	P
Ages 0-2	
No rescuer available	Y
Rescuer available	P
Ages 3-4	
No rescuer available	P
Rescuer available	U
Asleep	
Indication of movement (found partially or fully off the bed)	
≥ Age 85 (assumes burned by bedclothes)	P
Ages <5 Same as above categories	
Ages 5-9	
No rescuer available	U
Rescuer available	U
Other Ages	
With Limiting Conditions (inc drugs, alcohol, mental incapacitation)	P
Without Limiting Conditions	U
Not Asleep	
Ages < 5 Same as above	
≥ Age 85	
With Limiting Conditions	P
Without Limiting Conditions	U
Ages 5-9	
No rescuer available	U
Rescuer available	U
Other Ages	
With Limiting Conditions	P
Without Limiting conditions	U

Legend: Likelihood of a Casualty Occurring
Y= Injury Certain (1)
L= Likely (.75 - .85)
P=Possible (.45 - .55)
U=Unlikely (.1 - .2)
N=None (0)

Table C-2(continued)
Current Injuries

In Room of Origin, Not Intimate with Ignition	
Unable to Act (takes precedence)	
Restrained or Severe Physical Disablement	
No rescuer available	L
Rescuer available	U
Ages 0-2	
No rescuer available	L
Rescuer available	U
Ages 3-4	
No rescuer available	P
Rescuer available	U
Asleep	
≥ Age 85	U
Ages <5 Same as above	
Ages 5-9	
No rescuer available	U
Rescuer available	U
Other Ages	
With Limiting Conditions (inc drugs, alcohol, mental incapacity)	U
Without Limiting Conditions	N
Not Asleep	
Ages < 5. Same as above	
≥ Age 85	
With Limiting Conditions	U
Without Limiting Conditions	N
Ages 5-9	
No rescuer available	U
Rescuer available	N
Other Ages	
With Limiting Conditions	N
Without Limiting Conditions	N
Not in Room of Origin	
Physically Restrained, Severe Physical Disablement,	
Including ≤ age 2 with no rescuer	U
Other	
Not Entered Room	N
Entered Room of Origin Before Extinguishment	U
Fighting Fire, Regardless of Initial Location, Condition	U

Legend: Likelihood of a Casualty Occurring
Y= Injury Certain(1)
L= Likely (.75 - .85)
P=Possible (.45 - .55)
U=Unlikely (.1 - .2)
N=None (0)
Source: U.S. Consumer Product Safety Commission

Appendix D

Table D-1

Addressable Mattress/Bedding Deaths
CPSC Investigation Reports, 1/99 to 6/04

Age Group & Victim Location	Total	Ignition Type		
		Smoking	Open Flame	Other
Total	195	60	86	49
LT Age 5	65	2	44	19
Intimate with Ignition	31	0	26	5
In Room of Origin-Not Intimate	10	0	5	5
Outside Room of Origin	24	2	13	9
Location Unknown	0	0	0	0
Ages 5 to 14	31	4	18	9
Intimate with Ignition	9	0	6	3
In Room of Origin-Not Intimate	5	0	2	3
Outside Room of Origin	17	4	10	3
Location Unknown	0	0	0	0
Ages 15 to 64*	58	32	17	9
Intimate with Ignition	38	23	8	7
In Room of Origin-Not Intimate	2	0	2	0
Outside Room of Origin	15	6	7	2
Location Unknown	3	3	0	0
Ages 65+	41	22	7	12
Intimate with Ignition	27	17	4	6
In Room of Origin-Not Intimate	2	0	1	1
Outside Room of Origin	12	5	2	5
Location Unknown	0	0	0	0

*Includes 1 adult of unknown age

Note: Includes only deaths in fires attended by the fire service.

U.S. Consumer Product Safety Commission

Table D-2

Addressable Mattress/Bedding Injuries
CPSC Investigation Reports, 1/99 to 6/04

Age Group & Victim Location	Total	Ignition Type		
		Smoking	Open Flame	Other
Total	205	27	132	46
Child, Age Unknown	3	0	0	3
Intimate with Ignition	0	0	0	0
In Room of Origin-Not Intimate	0	0	0	0
Outside Room of Origin	3	0	0	3
Location Unknown	0	0	0	0
LT Age 5	39	2	33	4
Intimate with Ignition	17	0	16	1
In Room of Origin-Not Intimate	10	1	7	2
Outside Room of Origin	9	1	8	0
Location Unknown	3	0	2	1
Ages 5 to 14	24	2	15	7
Intimate with Ignition	12	0	9	3
In Room of Origin-Not Intimate	4	0	2	2
Outside Room of Origin	7	2	3	2
Location Unknown	1	0	1	0
Ages 15 to 64	86	14	49	23
Intimate with Ignition	32	5	16	11
In Room of Origin-Not Intimate	5	1	0	4
Outside Room of Origin	45	7	30	8
Location Unknown	4	1	3	0
Ages 65+	13	5	3	5
Intimate with Ignition	6	1	2	3
In Room of Origin-Not Intimate	4	2	0	2
Outside Room of Origin	2	1	1	0
Location Unknown	1	1	0	0
Adult, Age Unknown	40	4	32	4
Intimate with Ignition	5	0	4	1
In Room of Origin-Not Intimate	2	0	2	0
Outside Room of Origin	32	3	26	3
Location Unknown	1	1	0	0

Note: Includes only injuries in fires attended by the fire service.
U.S. Consumer Product Safety Commission

Table D-3

Estimated Reduction
Addressable Mattress/Bedding Deaths
Based on CPSC Investigation Reports
1/99 to 6/04

Age Group & Victim Location	Total	Ignition Type		
		Smoking	Open Flame	Other
Total	80% - 86%	74% -80%	83% - 89%	81% - 87%
LT Age 5	85% - 92%	100%*	83% - 90%	87% - 94%
At Point of Ignition	77% - 87%	**	76% - 86%	80% - 90%*
In Room of Origin-Not at Point of Ignition	79% - 89%	**	78% - 88%*	80% - 90%*
Outside Room of Origin	98% - 99%	100%*	98% - 99%	96% - 98%*
Location Unknown	**	**	**	**
Ages 5 to 14	94% - 97%	100%*	94% - 97%	91% - 96%*
At Point of Ignition	82% - 91%	**	83% - 92%*	80% - 90%*
In Room of Origin-Not at Point of Ignition	96% - 98%*	**	100%*	93% - 97%*
Outside Room of Origin	100%	100%*	100%	100%*
Location Unknown	**	**	**	**
Ages 15 to 64*	74% - 80%	72% - 79%	81% - 85%	68% - 74%*
At Point of Ignition	62% - 70%	63% - 71%	61% - 70%*	58% - 67%*
In Room of Origin-Not at Point of Ignition	90% - 95%*	**	90% – 95%*	**
Outside Room of Origin	100%	100%*	100%*	100%
Location Unknown	90% - 95%*	90% - 95%*	**	**
Ages 65+	69% - 75%	68% - 76%	62% - 66%*	74% - 79%
At Point of Ignition	54% - 62%	60% - 69%	34% - 41%*	49% - 58%*
In Room of Origin-Not at Point of Ignition	100%*	**	100%*	100%*
Outside Room of Origin	98% - 99%	96% - 98%*	100%*	100%*
Location Unknown	**	**	**	**

* Fewer than 10 investigations

** No incidents among investigations

Source: U.S. Consumer Product Safety Commission

Table D-4

Range of Estimated Reductions Addressable Mattress/Bedding Injuries Based on CPSC Investigation Reports 1/99 to 6/04

Age Group & Victim Location	Total	Ignition Type		
		Smoking	Open Flame	Other
Total	86% - 92%	87% - 92%	86% - 92%	85% - 92%
LT Age 5	80% - 87%	90% - 95%*	80% - 87%	76% - 82%*
At Point of Ignition	69% - 78%	**	71% - 80%	45% - 55%*
In Room of Origin-Not at Point of Ignition	82% - 91%	80% - 90%*	83% - 91%*	80% - 90%*
Outside Room of Origin	98% - 99%	100*	98% - 99%*	**
Location Unknown	72% - 78%*	**	72% - 78%*	72% - 78%*
Ages 5 to 14	88% - 94%	100%*	86% - 92%	89% - 94%*
At Point of Ignition	80% - 90%	**	80% - 90%*	80% - 90%*
In Room of Origin-Not at Point of Ignition	95% - 98%*	**	100%*	90% - 95%*
Outside Room of Origin	98% - 99%*	100%*	100%*	96% - 98%*
Location Unknown	72% - 78%*	**	72% - 78%*	**
Ages 15 to 64*	87% - 93%	86% - 91%	89% - 94%	85% - 92%
At Point of Ignition	77% - 87%	66% - 76%*	78% - 88%	80% - 90%
In Room of Origin-Not at Point of Ignition	98% - 99%*	100%*	90% - 95%*	96% - 100%*
Outside Room of Origin	92% - 96%	96% - 98%*	93% - 96%	85% - 93%
Location Unknown	88% - 94%*	80% - 90%*	90% - 95%*	**
Ages 65+	87% - 91%	85% - 92%*	82% - 88%*	85% - 93%*
At Point of Ignition	76% - 85%*	80% - 90%*	62% - 72%*	80% - 90%*
In Room of Origin-Not at Point of Ignition	86% - 93%*	80% - 90%*	**	90% - 95%*
Outside Room of Origin	98% - 99%*	99% *	98% - 99%	**
Location Unknown	80% - 90%*	80% - 90%*	**	**

Note: Adults and children of unknown ages were allocated proportionally to the adult or child categories.

* Fewer than 10 investigations

** No investigation injuries in this category

Source: U.S. Consumer Product Safety Commission

Table D-5
Estimated Residential Structure Fires and Fire Losses, 1993 – 2002

Year	Fires	Deaths	Injuries	Property Loss (millions)
1993	470,000	3,825	22,600	$4,843
1994	451,000	3,465	20,025	$4,317
1995	425,000	3,695	19,125	$4,363
1996	428,000	4,080	19,300	$4,962
1997	406,500	3,390	17,775	$4,585
1998	381,500	3,250	17,175	$4,391
1999	383,000	2,920	16,425	$5,092
2000	379,500	3,445	17,400	$5,674
2001	396,500	3,140	15,575	$5,643
2002	401,000	2,695	14,050	$6,055

Source: National Fire Protection Association annual sample survey. See methodology in *NFPA Journal*, September/October 2003, pp 59 – 63.

Tab D

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: October 14, 2004

TO : Margaret Neily, Project Manager, Mattress/Bedding
Directorate for Engineering Sciences

THROUGH: Hugh McLaurin, Associate Executive Director
Directorate for Engineering Sciences

FROM : Carolyn Meiers, Engineering Psychologist
Directorate for Engineering Sciences

SUBJECT : Criteria for Judging Effectiveness of Proposed Mattress Standard

This memo addresses the methodology used to assess the potential effectiveness of the U.S. Consumer Product Safety Commission (CPSC) staff's draft proposed mattress standard. The staff analyzed in-depth investigations of mattress fires and compared conditions that characterized the investigated fries with conditions that could be expected had the fires involved mattresses that complied with the proposed draft flammability requirements. The objective of this analysis was to determine if the draft flammability requirements would be effective in reducing deaths and injuries. A conservative approach was adopted when analyzing cases with unknown variables.

A set of criteria was developed to make comparisons between the two fire scenarios. Criteria were based, in part, on known fire characteristics exhibited by mattresses that comply with current cigarette ignition flammability requirements and predicted fire characteristics expected of mattresses that would comply with the staff's drafted open-flame flammability requirements, including tenability limits of combustion products and the phenomenon of flashover. [1] Criteria were also based on the characteristics of the occupants involved in the fires and the environments in which the fires occurred.

This memo also discusses the rationale for choosing criteria pertaining to the characteristics of the occupants and the environment in which the fires occurred. These characteristics include the age of the occupants, whether they were asleep or awake, whether there was a potential rescuer in the household, whether there were limiting conditions such as drugs, alcohol, or disabilities, and whether the occupants attempted to fight the fire. Location of occupants with respect to point of ignition and room of fire origin, as reported in the in-depth-

[1] Tenney, Allyson. 2004. Background and Technical Rationale for Draft Proposed Standard for Open-Flame Mattress Flammability. U.S. Consumer Product Safety Commission: Washington D.C.

investigations, was used to assess the behaviors of occupants during the fire event and predict how the draft proposed flammability requirements might affect the outcomes of these behaviors.

Age Criteria: The very young and the very old are particularly susceptible to death and injury from fire, typically because of the limited physical and cognitive abilities associated with these age spectra. Therefore, age was a factor in considering whether a death or injury would occur under the staff's draft proposed mattress standard.

Children were divided into three developmental age groups: 0 to 2 years, 3 to 4 years, and 5 to 9 years. The 0 to 2 year group reflects children who would not be able to perform self-rescue attempts or be able to communicate their situation to rescuers. Children aged 3 to 4 years are, in some circumstances, better able to respond in an appropriate manner to a fire situation although some will still hide or refuse to leave the residence. The age group of 5 to 9 years is a traditional age breakdown used in statistical fire studies. While children in this age range could be expected to flee from a burning home, some still adversely react to a fire by seeking shelter in another room or running back into the residence after breaking away from those helping them to exit.

The likelihood of death or injury occurring to children in these age ranges was categorized according to the other circumstances of the fire event. These include situations where the children may have been restrained in some way or may have suffered from a severe physical disability, and situations where the presence of a rescuer in the residence may have made a difference. Children under the age of 2 with no rescuer in the residence were considered more susceptible to death or injury than older children with no rescuer present. It was assumed that the draft proposed standard would not alter the possibility of an injury occurring under these circumstances.

State-of-Consciousness Criteria: Criteria also took into consideration whether the child or adult was awake or asleep since these conditions may affect how quickly someone could respond to a fire situation. Also, among those initially asleep, a distinction was made between those who awoke and those who did not. If there was an "indication of movement" meaning the body was found either partially or fully off the bed, it was inferred that the occupant awoke and attempted to elude the fire. Occupants found in this condition were considered less likely to die in fires involving mattresses complying with the draft proposed standard because they would have more time to react.

If an occupant was found on the bed, it was inferred that limiting conditions, such as alcohol or drugs, prohibited the victim from becoming aware of the fire. Under such conditions, increasing the length of time for escape (as intended in the proposed draft standard) was not expected to alter the victim's behavior because the lack of responsiveness to the fire environment would remain the same.

Special consideration was given to the elderly when developing criteria for effectiveness. It was decided to apply an age criterion to victims to reflect the physical and cognitive responsiveness of the elderly in fire situations. Victims over the age of 85 were considered more

vulnerable to death and injury based on research findings that indicate they have a fire death rate that is four times the national average. [2]

Limiting Conditions Criteria: The presence of limiting conditions such as drugs and alcohol were taken into account, not only for the elderly, but for all ages when these conditions were known. Alcohol can diminish an occupant's ability to detect a fire because of interference with the sensory mechanisms of smell and hearing. Disruption of motor coordination and mental clarity caused by alcohol consumption increases the likelihood that the user will start a fire and decreases the likelihood that the person will be able to mitigate or escape the fire.

Mobility impairments were also taken into account when assessing behavioral expectations of occupants. Persons in this category are at a high risk of dying in a fire because home construction features may present impediments to escape and impairments may hinder attempts to contain or put out a fire. A rescuer(s) may not be present to assist with escape at the time of a fire and an occupant may be trapped inside the dwelling.

Domestic Firefighting Criteria: Whenever domestic firefighting behavior was reported, it was assumed that the occupant would sustain some type of injury albeit minor. This assumption is based on fire studies that state "Very few people are killed trying to fight fires... For fire victims who are injured, however, the activity profile is sharply different. The leading activity when injured is "fire control," that is, trying to put out or contain the fire. The best estimate is that over one-third of fire injuries are occurring from this problem alone. Injuries while trying to escape are second." [3] Conservatively, it was assumed that the draft proposed mattress requirements would not have a significant impact in reducing injuries incurred during domestic firefighting.

Location of Occupants Criteria: The criteria also provided that because the proposed draft mattress standard is expected to reduce the potential for flashover (the engulfing of all contents of a room and subsequent spread of the fire,), occupants located outside the room of origin would be more likely to escape death. However, if they return to the room to fight the fire, or to perform a rescue, they may still be injured or killed.

It was common to have several criteria involved in a single fire incident. For instance, age, alcohol, and state of consciousness might all have been factors in a specific mattress fire. In these instances, the interactions of the criteria were assessed to determine how they might be altered in fire situations that involved mattresses adhering to the draft proposed flammability requirements.

Using the selected criteria, the conditions occurring with mattresses adhering to the draft proposed requirements were assigned to one of five categories: a death or injury would still occur, would likely occur, would possibly occur, would be unlikely to occur, or would not occur.

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[2] Fire Risks for Older Adults. (October 1999). United States Fire Administration: Emmitsburg MD, pp.3-4.

[3] "Fire in the United States 1983-1990, Eighth Edition. (October 1993). National Fire Data Center, United States Fire Administration: Emmitsburg, MD, p.238.

A range of probabilities was then assigned to each category to estimate the probable effectiveness of the standard.[4]

[4] Smith, Linda and Miller, David. (2004). Residential Fires Involving Mattresses and Bedding. U.S. Consumer Product Safety Commission: Washington DC.

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

October 7, 2004

TO : Margaret Neily, Director
Division of Combustion and Fire Sciences
Directorate for Engineering Sciences

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SUBJECT : Human Behavior in Fire

PURPOSE

The U.S. Consumer Product Safety Commission (CPSC), in cooperation with other government agencies and industry representatives, is developing mandatory performance requirements to address mattress flammability. In support of this project, this memo is intended to serve as a reference for analyzing the potential effectiveness of mattress performance options by identifying the factors that can affect egress time. Several of these factors have been used to establish criteria on which to make comparisons between the current flammability performance of mattresses and the staff's draft proposed flammability requirements.

BACKGROUND

Each fire event is unique. The behaviors of the occupants, the behavior of the fire, and the characteristics of the environment in which the fire event occurs, are different for every fire situation. Nevertheless, all fire events in which occupants are involved adhere to a time framework comprised of three sequential phases (detection, pre-movement, and egress times) that, taken together, represent total evacuation time. The following equation illustrates this relationship.

Detection Time + Pre-Movement Time + Egress Time = Total Evacuation Time

The behaviors of occupants, the characteristics of fire events, and the concept of total evacuation time will be discussed in the following sections of this memo. The memo will also discuss how these behaviors and characteristics can affect the total evacuation times for single-family dwellings.

DISCUSSION

Fire events should be analyzed using a systems approach that recognizes the contributions of occupant behavior, fire behavior and the environment. The characteristics inherent in these categories are not insular; a systems approach to fire events fundamentally represents a chain reaction of dependencies. Occupant behavior can be dependent upon the stages of fire growth that, in turn, can be dependent on the structural features in the environment.

> "It must be recognized that an individual's behavior in a fire is affected by the variables of the building in which the fire occurs and by the appearance of the fire at the time of detection. For example, the occupants' response will vary if they smell smoke rather than see flames or dark, acrid smoke completely obscuring a corridor." (6)

It is the complex nature of the interactions among the disparate characteristics that makes the quantification of evacuation times difficult. Similar behavior replicated under different conditions can produce significant variations in evacuation times.

The three phases of evacuation time introduced above (detection, pre-movement, egress) are qualitative divisions on a timeline. While, "Time is the basic measure of the evacuation process" (9, p. 1), quantitative values cannot be assigned to the phases. Current research does not provide this type of data for single-family dwellings (14) (15) (9). The scarcity in evacuation time data is due, in part, to the relatively rare and unpredictable occurrences of fires and the difficulty in measuring the short time intervals in which crucial reactions occur (20). Each of the three time phases that comprise the total evacuation time from a dwelling are described in Section A of this memo.

Arrow charts that depict the interactions of occupant behavior, fire characteristics, and the fire environment within the different time phases are located at Section B. The arrow charts represent an amalgam of characteristics derived from various fire research literature listed in the reference section of this memo.

Section C uses citations from the fire literature to expand on issues concerning occupant, fire, and environmental characteristics that were addressed in the arrow charts.

SECTION A

Time Phases Comprising Total Evacuation Time

Detection Time: This is the time period in a fire event before the occupant(s) are aware that a fire has begun. The detection time phase begins at ignition and continues until the fire is first detected. Detection fundamentally depends on the type and strength of the fire and alarm cues and the occupant(s)' perceptual and interpretative capabilities. Time to detection is also dependent on the location of the occupant(s) in regard to the source of ignition – whether the occupant(s) is in the room of origin or in farther reaches of the residence.

"Lengthy delays occur before people realize there is a fire. Even when people suspect that a fire exists, they are reluctant to do anything until they have checked" (20, p. 407). However, the first cue may be interpreted as some other occurrence" (21, p.176).

Strange noises can often be the first indication of a fire (20), but may not be recognized as such by the occupant(s). Some evidence suggests that noise cues, such as glass breaking, are often initially attributed to break-ins. Occupant(s) appear to "have a greater fear of being burgled at home than of a fire occurring" (21, p.176). Other research has found that, "Visual detection of smoke and less frequently of flames predominates in domestic fires" (20, p.414).

One fire researcher considers this time period critical: "Any calculation of evacuation time from a dwelling is meaningless because the crucial time is how long it takes to recognize the existence of the fire and act on it. By then there is either time to get out or it's too late" (13).

There is no effective way to quantify the time lapse between ignition and detection for fire events in single family dwellings because ignition time is not likely to be known. However, "There is considerable evidence in the literature that occupants do not respond within seconds to the initial cues of a fire" (9, p.12).

Pre-Movement Time: This time period begins with the first detection of a fire cue(s) and continues until the occupant(s) begins to move toward an exit. During this time, occupant(s) are not escaping the fire but are investigating detected cues and then performing various actions in preparation to leaving the dwelling after the existence of a fire has been verified.

"After the cue validation time period, it is possible that occupants will begin to proceed directly to building exits; however, it is known that such movement may often be delayed as a result of occupant decisions to perform other actions deemed important" (9, p.6). Fire growth and spread can restrict options for movement.

Occupant(s) must make critical decisions in an unstable, unhealthy and unsafe environment during a time of ambiguous, rapidly changing circumstances. One researcher states that, "...early behavior is characterized by uncertainty, misinterpretation, indecisiveness and seeking confirmation" (20, p.407). "Even in less serious fires there is some degree of ambiguity in the early stages of a fire and people search out information about the fire" (20, p.405). It has been observed that "most people need at least information from two different sources before the situation can be defined" (21, p.177).

It is difficult to quantify pre-movement time. One of the reasons is that, "There is limited information available concerning the time people spend to make individual decisions" (9, p.13).

Egress Time: This time period begins once the occupant(s) have completed pre-movement activities and start to travel to an exit. The time period ends once the occupant(s) are outside of the dwelling in a place of safety.

SECTION B

Interaction of Occupant, Fire, and Environmental Characteristics within Certain Time Phases

Components of Total Evacuation Time: **Detection Time: Ignition to Detection of Fire**

Time Interval Dependent On...

OCCUPANT CHARACTERISTICS

Activity at time of ignition	Activities that elicit focused attention and concentration, such as working at a computer or watching a movie may delay awareness of fire cues.
Asleep or awake	Response times to fire cues or alarms can be considerably delayed if occupant(s) are asleep.
Drug/alcohol use	Influence of drugs and/or alcohol may impact cognitive functions such as reasoning and judgment and delay recognition of fire cues.
Location of fire in relation to occupant(s)	The farther the occupant(s) are away from the fire the longer it can take to detect it.
Age	Cognitive and sensory abilities of the very young and very old can affect their ability to detect signs of a fire or alarm cues.
Sensory Limitations	Sensory limitations (smell, hearing) may impact abilities to detect fire cues.
Alone or With Others	Occupants who are alone will investigate ambiguous cues more quickly than if others are present.
Susceptibility to combustion products	Susceptibility to combustion products may impact awareness and judgment of fire cues.

FIRE CHARACTERISTICS

Fire Growth	The strength of fire cues may affect how soon they can be detected. Fire could be well established by the time a cue is sensed.

ENVIRONMENTAL CHARACTERISTICS

Smoke alarms	Examples of a few issues with smoke alarms that can affect detection time include whether the smoke alarm/s was operable at the time of the incident, and, if so, whether the signal was received and recognized, and how the occupant(s) reacted to the signal. The number and location of smoke alarms is an additional issue.
Location of occupant(s)	The farther occupants are located from a fire the longer it can take to detect fire cues.

Components of Total Evacuation Time: **Pre-Movement Time: Detection of Fire to Initiation Of Egress** - Time Interval Dependent On...

OCCUPANT CHARACTERISTICS

Investigation/ Validation	"After fire ignition and detection, occupants will spend several seconds, if not minutes, in non-evacuation actions...investigating and finding information to interpret the perceived cue." (14) At some point, the fire department may be contacted.
Sensory limitations	Sensory limitations (hearing, seeing) could impair or delay performance of pre-movement actions.
Type of activity engaged in prior to detection	If occupant(s) were engaged in behaviors such as sleeping or showering prior to detection, additional time may be spent in dressing for the outdoors, particularly if the weather is cold.
Drug/alcohol use	Drug and alcohol use can impair cognitive abilities, such as decision-making, and physical abilities needed to perform pre-movement activities.
Gender/Role	Generally, women are more likely to warn and gather other occupants before leaving the dwelling and men are more likely to stay and attempt to extinguish the fire. However, actions can also be dependent on roles.
Alone or with others	The presence of others can hinder decision-making, but increase the opportunity to warn and gather others.
Warning, alerting, and rescuing.	Some occupants, especially children, do not reliably respond to smoke alarms and will have to be found and awoken. Other occupants may have to be located and rescued. Some occupants may rescue pets.
Training	Training in what to do in a fire situation may prepare an occupant(s) to raise an alarm and to organize an evacuation more quickly than someone without training.
Previous experience in a fire situation	Those who have had a previous experience with a fire may be more likely to stay and try to fight the fire. They may be less likely to leave the dwelling immediately.
Age	Cognitive abilities of the very young and very old may limit their capacity to make informed, rational responses to the ever-changing and ambiguous nature of the fire.
Mobility impairment	Limitations in mobility can affect the pace at which pre-movement activities are performed.
Gathering belongings	Occupant(s) may gather up wallets, purses, and other belongings before they exit the dwelling.

FIRE CHARACTERISTICS

Fire Growth	Decision on whether to attempt to fight the fire or evacuate will depend on the stage of fire growth. The more serious a fire is perceived to be the more likely occupant(s) are to immediately evacuate and not try to fight the fire. Fire growth may hamper or prevent the performance of other pre-movement activities.
Fire Spread	Occupant(s) may change ventilation conditions during the investigative process (open or close doors and windows) that could deter or encourage fire spread.
Smoke	The presence of smoke may affect visibility and prolong or hinder pre-movement efforts.
Susceptibility to combustion gases	Combustion gases emitted from the fire may affect the occupant(s).

ENVIRONMENTAL CHARACTERISTICS

Familiarity with dwelling	Familiarity with the dwelling may facilitate the performance of pre-movement efforts, whereas unfamiliarity can prolong or hinder efforts. Also, the degree of familiarity with a dwelling may generate a level of confidence that results in occupant(s) attempting activities such as firefighting or retrieving objects. Occupant(s), knowing where the exits are, may be more confident in their assessment of the time needed to exit. Those unfamiliar with a dwelling may consider that fact and may attempt to exit immediately. They may also have less "emotional attachment" to the contents of the dwelling and be less likely to spend time protecting or gathering belongings.
Location of safety equipment	Finding fire extinguishers and other types of extinguishing materials or locating and setting up a fire ladder can be part of the pre-movement activities that delay time to exit.
Weather	The occupant(s) may take time to dress for the outdoor environment before they exit, such as putting on jackets if it is cold.
Travel Time	The layout of the dwelling and the location of persons and objects (phone, clothes, personal effects) can affect the time necessary to accomplish the occupant(s) activities.

Components of Total Evacuation Time: **Egress Time: Time required to exit the structure after pre-movement activities completed**

Time Interval Dependent On...

OCCUPANT CHARACTERISTICS

Movement under smoke and heat conditions	The density, amount, and toxic properties of smoke and heat can slow the occupant(s) speed of egress.
Debilitating conditions	Debilitating conditions, such as physical and mental handicaps, drug and alcohol use, and sensory and mobility limitations can affect the speed of departure.
Susceptibility to combustion gases	Occupant(s) susceptibility to combustion gases can affect ability to exit safely.
Alone or with others	The slowest member of a group may dictate the speed of movement.

FIRE CHARACTERISTICS

Fire Growth	Excessive smoke, flames and heat can affect visibility, render exits unusable, and the combustion by-products can physically deplete occupants.

ENVIRONMENTAL CHARACTERISTICS

Familiarity with structure	Familiarity with the structure may facilitate evacuation because location of stairs, windows, exits, and obstacles are known. Whereas, unfamiliarity with a structure may delay departure.
Exits	The layout of a dwelling may limit the number of available avenues of escape. Some layouts of manufactured homes may offer limited means of egress. Some windows have protective bars that prohibit escape from inside the room. Certain types of door locks may be harder for occupants to open quickly.
Stairs	Stairs can be an impediment to those with mobility impairments.
Travel Distance	Travel distance is dependent upon the locations of the occupant(s), room of fire origin, and nearest usable exit.