

Table 4  
National Estimates of Residential Fires, Civilian Casualties, and Property Loss  
Associated With All Mattress / Bedding Fires by Ignition Source 1980 - 1998

	YEAR									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	
<b>Total Mattress and Bedding</b>	510	580	580	570	460	490	610	490	390	
Smoking Material	290	260	300	320	210	260	300	230	230	
Candles, Matches, Lighters	120	180	180	180	180	130	120	120	90	
Additional Small Open Flame Sources	20	20	20	**	10	10	30	20	10	
Other In-Scope Ignition Sources	90	120	80	70	60	90	160	130	70	
Out-of-Scope Ignition Sources	--	**	10	--	10	--	**	**	**	
	FIRE DEATHS									
<b>Total Mattress and Bedding</b>	2,650	2,890	3,130	3,160	2,750	2,470	2,330	2,240	2,160	
Smoking Material	1,080	990	1,140	1,010	780	750	750	730	670	
Candles, Matches, Lighters	980	1,140	1,300	1,340	1,390	1,150	1,060	940	980	
Additional Small Open Flame Sources	20	60	60	80	20	40	50	40	30	
Other In-Scope Ignition Sources	540	680	590	710	530	500	440	510	460	
Out-of-Scope Ignition Sources	30	20	50	20	20	30	30	30	20	
	FIRE INJURIES									
<b>Total Mattress and Bedding</b>	25,600	25,900	25,600	25,500	24,700	21,400	21,100	19,200	18,100	
Smoking Material	9,400	9,000	8,500	7,900	7,300	6,400	6,400	5,400	5,400	
Candles, Matches, Lighters	8,300	8,800	9,500	9,700	10,000	8,000	7,600	6,800	6,500	
Additional Small Open Flame Sources	500	500	500	400	500	500	500	400	400	
Other In-Scope Ignition Sources	6,900	7,000	6,700	6,900	6,300	6,100	6,200	6,200	5,400	
Out-of-Scope Ignition Sources	500	500	400	500	500	500	500	500	400	
	FIRES									
<b>Total Mattress and Bedding</b>	\$233.0	\$300.7	\$210.7	\$262.3	\$236.0	\$219.9	\$245.0	\$217.0	\$208.3	
Smoking Material	\$85.7	\$104.5	\$70.0	\$81.2	\$69.5	\$65.8	\$73.8	\$60.5	\$62.1	
Candles, Matches, Lighters	\$75.6	\$102.8	\$78.2	\$100.1	\$95.9	\$81.8	\$87.9	\$77.1	\$74.9	
Additional Small Open Flame Sources	\$4.4	\$6.2	\$4.1	\$4.5	\$5.0	\$4.7	\$5.6	\$4.7	\$4.6	
Other In-Scope Ignition Sources	\$62.5	\$81.1	\$55.1	\$71.3	\$60.4	\$62.6	\$72.4	\$69.5	\$61.9	
Out-of-Scope Ignition Sources	\$4.8	\$6.2	\$3.4	\$5.2	\$5.1	\$5.1	\$5.2	\$5.2	\$4.7	
	PROPERTY LOSS (MILLIONS)									

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes  
 Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA)  
 Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (-) indicates that no NFIRS reports were received.  
 Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration

Table 5

Percent Change in National Estimates of Residential Fires, Civilian Casualties, and Property Loss Associated With In-Scope Mattress / Bedding Fires, Comparing 1980 and 1998

	1980	1998	% Change
<b>FIRE DEATHS</b>			
<u>Total Residential Fire Deaths</u>	5,446	3,250	-40%
Total In-Scope Mattress and Bedding Fire Deaths	830	390	-53%
Smoking Material	490	230	-53%
All Small Open Flame Sources	150	100	-33%
Other In-Scope Ignition Sources	180	70	-61%
<b>FIRE INJURIES</b>			
<u>Total Residential Fire Injuries</u>	21,100	17,175	-19%
Total In-Scope Mattress and Bedding Fire Injuries	2,940	2,090	-29%
Smoking Material	1,550	660	-57%
All Small Open Flame Sources	790	980	24%
Other In-Scope Ignition Sources	610	450	-26%
<b>FIRES</b>			
<u>Total Residential Fires</u>	757,500	381,500	-50%
Total In-Scope Mattress and Bedding Fires	57,000	17,300	-70%
Smoking Material	27,500	5,300	-81%
All Small Open Flame Sources	16,000	6,700	-58%
Other In-Scope Ignition Sources	13,500	5,200	-61%
<b>PROPERTY LOSS (MILLIONS)</b>			
<u>Total Residential Fire Property Loss</u>	\$3,042.0	\$4,391.0	44%
Total In-Scope Mattress and Bedding Property Loss	\$229.1	\$199.1	-13%
Smoking Material	\$110.5	\$61.3	-45%
All Small Open Flame Sources	\$64.4	\$77.4	20%
Other In-Scope Ignition Sources	\$54.1	\$60.4	12%

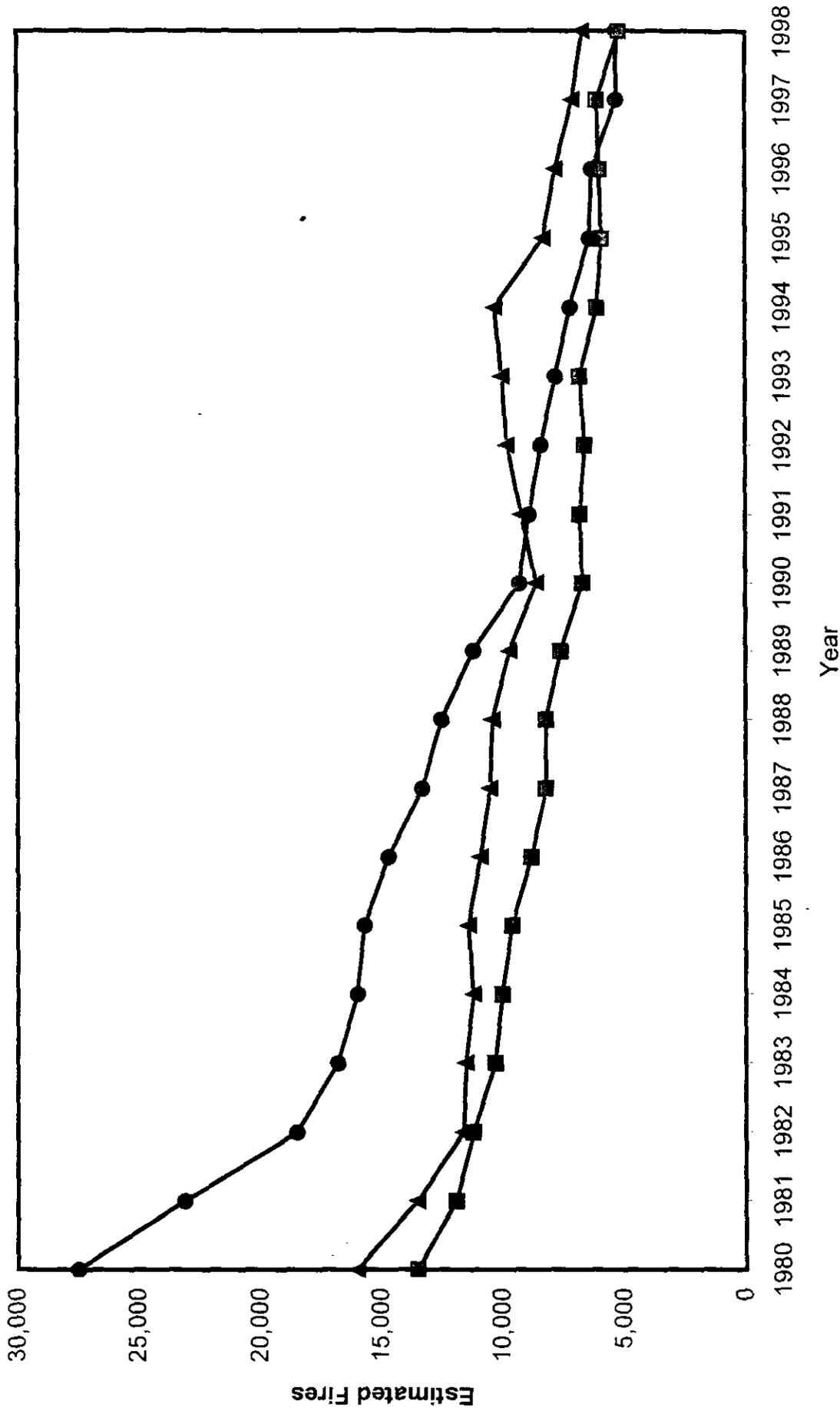
Notes: Smoking materials are cigarettes (primarily), cigars, and pipes.

Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA).

Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (--) indicates that no NFIRS reports were received.

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

**Figure 1**  
**In-Scope Mattress and Bedding Fires by Type of Ignition Source 1980 - 1998**



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

Fire deaths due to the ignition of mattress or bedding items by smoking materials also experienced a marked decrease; deaths from these fires fell from 490 deaths in 1980 to 230 deaths in 1998, a decline of 53%. Regression analysis showed this to be a significant downward trend ( $p < 0.05$ ). Small open flame ignited fire deaths have also declined since 1980 (a 33% decrease, 150 to 100), but the trend is not significant ( $p > 0.05$ ). Figure 2 graphically presents mattress and bedding fire deaths associated with the three categories of in-scope ignition sources: smoking materials, all small open flame sources (again, candles, matches, lighters were combined with additional small open flame sources), and other in-scope heat sources from 1980 to 1998.

### **C. Fire Casualties**

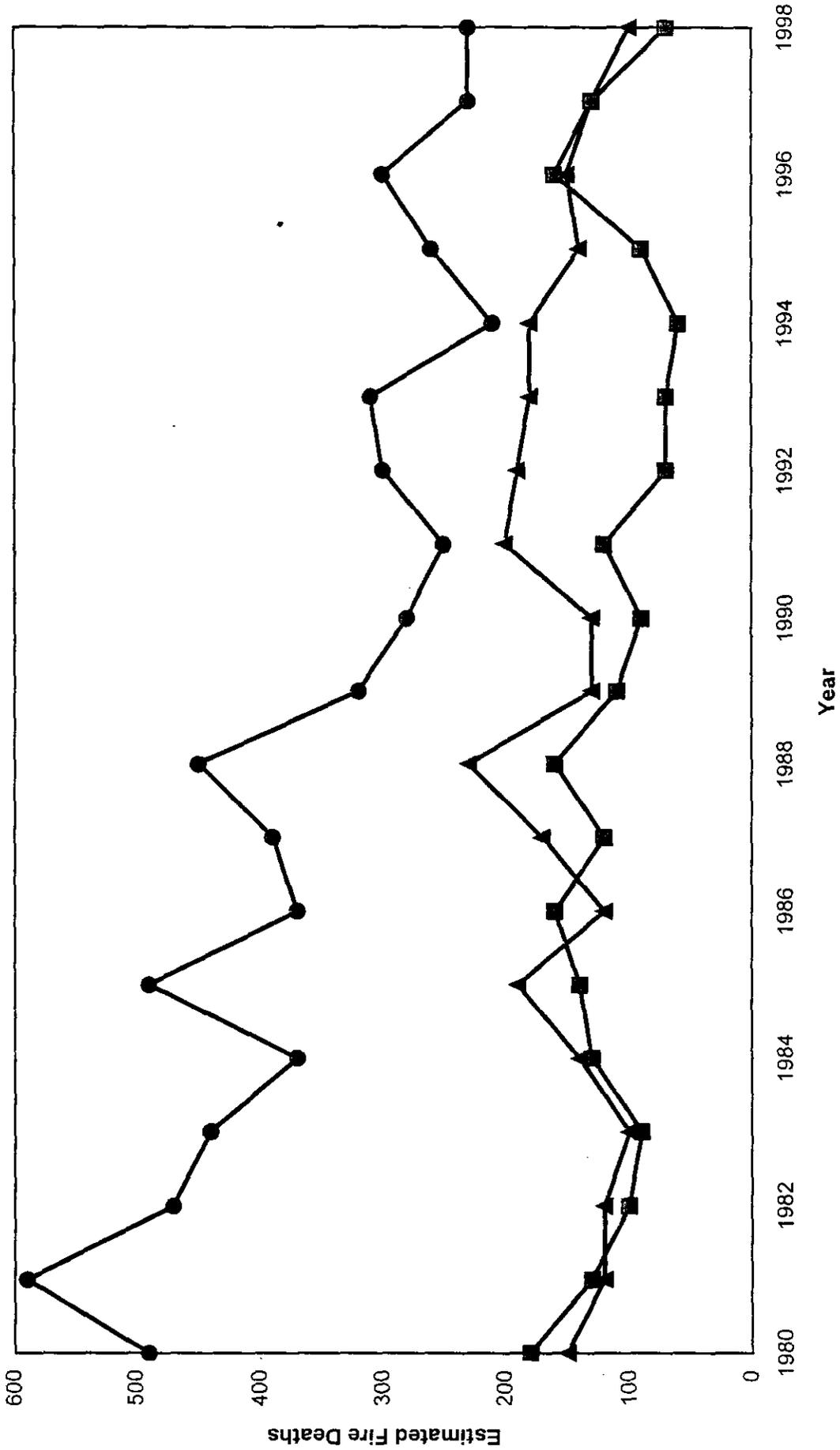
#### Location of Casualty at Time of Ignition

An appropriate indicator of how fire size affects fire casualties may be the location of a casualty at the time of ignition, in relation to the extent of the flame damage. The location of a fire casualty can be categorized into one of three groups. The first category, "intimately involved in ignition," includes casualties in direct contact with the first item ignited. The NFPA 901 coding manual definition states that for this category "included are ignition of clothing on a person and ignition of bedding or furniture on which a person is sitting or lying (Page 901-148)." The second classification includes victims not intimately involved in ignition, but "in the room or space of fire origin." The third category is comprised of victims not in the room of origin. This final category of casualties implies that the fire was severe enough to trigger flashover in the room of origin.

A promising approach to reducing fire casualties through a more comprehensive flammability standard for mattresses would be to develop a performance standard targeting the prevention of flashover. Although such a standard may not reduce the number of victims classified as "intimately involved in ignition," some reduction may occur for victims not intimate with ignition but in the room of fire origin, and certainly a reduction in victims outside the room of origin could reasonably be expected.

The percentage of in-scope mattress or bedding fire deaths and injuries occurring during the five year time period from 1994 to 1998 are displayed in Table 6 for each ignition source category according to victim location and the extent of flame damage in the fire. (Similar tables for mattresses, Table 5C, and bedding, Table 6C, are given separately in Appendix C.) The highlighted cells in each subtable of Table 6 represent the percentage of fire casualties not in the room of origin where the flame extended beyond the room of origin, fire casualties that an open flame flammability standard targeting the reduction of heat release would likely affect. For all in-scope mattress/bedding fire scenarios, 34% (or about 160 deaths each year based on a 5-year annual average) of all mattress and bedding fire deaths and 28% (650 injuries/year) of injuries would certainly be addressable by a standard intended to prevent flashover. There are two additional categories of casualties that are also likely to be affected by an open flame standard designed to reduce the heat release of a mattress. The

**Figure 2**  
**In-Scope Mattress and Bedding Fire Deaths by Type of Ignition Source 1980 - 1998**



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

Table 6  
 Percentage of Civilian Casualties Associated With In-Scope Mattress / Bedding Fires  
 Victim Location by Extent of Flame Damage 1994 - 1998

	Deaths		Injuries	
	Flame Confined to Room of Origin	Flame Beyond Room of Origin	Flame Confined to Room of Origin	Flame Beyond Room of Origin
<b>All In-Scope Mattress and Bedding Fires</b>				
Victim Intimate with Ignition	Annual Estimate 480	Annual Estimate 480	Annual Estimate 2,320	Annual Estimate 2,320
Not intimate but in room of origin	10%	14%	12%	7%
Not in room of origin	13%	24%	17%	13%
Unclassified	5%	34%	22%	28%
	0%	--	0%	0%
<b>Smoking Material</b>				
Victim Intimate with Ignition	Annual Estimate 240	Annual Estimate 240	Annual Estimate 730	Annual Estimate 730
Not intimate but in room of origin	13%	19%	17%	10%
Not in room of origin	16%	19%	18%	12%
Unclassified	6%	27%	18%	25%
	0%	--	0%	1%
<b>All Small Open Flame Sources</b>				
Victim Intimate with Ignition	Annual Estimate 140	Annual Estimate 140	Annual Estimate 1,110	Annual Estimate 1,110
Not intimate but in room of origin	8%	11%	10%	5%
Not in room of origin	12%	26%	16%	13%
Unclassified	3%	40%	26%	30%
	--	--	0%	0%
<b>Other In-Scope Ignition Sources</b>				
Victim Intimate with Ignition	Annual Estimate 100	Annual Estimate 100	Annual Estimate 480	Annual Estimate 480
Not intimate but in room of origin	5%	8%	8%	7%
Not in room of origin	6%	33%	20%	12%
Unclassified	4%	43%	23%	30%
	--	--	--	--

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes.  
 Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates from a survey conducted by the National Fire Protection Association (NFPA). Estimates are based on a 5 year average from 1994 through 1998.  
 Due to rounding, detail may not add to total.  
 Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration.

percentage of victims not in the room of origin where flame damage was confined to the room of origin, and to victims not intimate with ignition but in the room of origin where the flame extended beyond the room of origin (bolded cells) are also addressable by an open flame standard. For in-scope mattress/bedding fires, the percentages of deaths affected by these categories are 5% (20 deaths/year) and 24% (120 deaths/year), respectively, and 22% (510 injuries/year) and 13% (300 injuries/year) for injuries. Thus, the total percentage of mattress/bedding fire deaths addressable by an open flame standard preventing flashover is 63% (300 deaths/year) and the percentage of injuries is also 63% (1,460 injuries/year).

Ignition by smoking materials accounted for almost 60% of the deaths and about 30% of the injuries in all mattress and bedding fires in 1998. The current cigarette ignition standard attempts to address all of these fires. Yet, the existing standard is more effective at addressing a specific type of mattress fire in which a smoldering cigarette first ignites a mattress. Due to the complexities involved in a fire scenario and the fact that a bed is, typically, a system of materials that may include sheets, blankets, and/or comforters, rather than simply a bare mattress, determining which item, i.e. a mattress or bedding item, ignited first is often impossible. A fire in which a cigarette ignites bedding materials, which in turn ignite the mattress, is a case that may not be adequately covered by the current standard but would be covered by an open flame standard designed to minimize heat release.

### Age of Casualties

Table 7 displays the age distribution of the estimated deaths and injuries for fires in which a mattress or bedding item was first to ignite based on a five-year average for the time period from 1994 to 1998. (Similar tables for mattresses, Table 7C, and bedding, Table 8C, are given separately in Appendix C.) The ignition source for 78% of the deaths to victims younger than age 5 was candles, matches, or lighters, and this same ignition source was responsible for two-thirds of the deaths among 5 to 14 year-olds. Mattress or bedding ignition due to smoking materials was the most common cause of death among victims 15 years of age and older.

For each age group, the percentage of mattress or bedding fire deaths and injuries occurring during the five year time period from 1994 to 1998 are displayed in Table 8 according to victim location and the extent of flame damage in the fire. (Similar tables for mattresses, Table 9C, and bedding, Table 10C, are given separately in Appendix C.) Again, the highlighted cells in each subtable of Table 8 represent the percentage of fire casualties not in the room of origin where the flame extended beyond the room of origin; fire casualties that an open flame flammability standard would likely affect. For children under 5 years of age involved in in-scope mattress/bedding fire scenarios, 38% of deaths (approximately 30 deaths/year based on a 5-year annual average) and 23% of injuries (50 injuries/year) are preventable with an open flame standard designed to prevent flashover. The bolded cells corresponding to the percentage of victims not in the room of origin where flame damage was confined to the room of origin and to

Table 7  
National Estimates of Civilian Casualties Associated With In-Scope Mattress / Bedding Fires  
by Age Group 1994 - 1998

	AGE				
	Total	Under 5	5 to 14	15 to 64	65 and Older
<b>Total In-Scope Mattress and Bedding Fire Deaths</b>					
Smoking Material	480	90	30	220	140
Candles, Matches, Lighters	240	10	**	150	80
Additional Small Open Flame Sources	120	70	20	20	**
Other In-Scope Ignition Sources	20	**	**	10	10
	100	10	10	30	40
<b>Total In-Scope Mattress and Bedding Fire Injuries</b>					
Smoking Material	2,320	220	260	1,560	280
Candles, Matches, Lighters	730	10	30	560	130
Additional Small Open Flame Sources	1,080	190	170	650	70
Other In-Scope Ignition Sources	40	**	10	30	**
	480	30	60	310	80

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes. Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA). Estimates are based on a 5-year average from 1994 through 1998. Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (-) indicates that no NFIRS reports were received. Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration.

Table 8  
 Percentage of Civilian Casualties Associated With In-Scope Mattress / Bedding Fires for Particular Age Groups  
 Victim Location by Extent of Flame Damage 1994 - 1998

	Deaths		Injuries	
	Flame Confined to Room of Origin	Flame Beyond Room of Origin	Flame Confined to Room of Origin	Flame Beyond Room of Origin
<u>Under 5 Years of Age</u>				
Victim Intimate with Ignition	Annual Estimate 90	Annual Estimate 90	Annual Estimate 220	Annual Estimate 220
Not intimate but in room of origin	8%	12%	16%	13%
Not in room of origin	9%	31%	12%	21%
Unclassified	2%	38%	14%	23%
	--	--	--	0%
<u>5 to 14 Years of Age</u>				
Victim Intimate with Ignition	Annual Estimate 30	Annual Estimate 30	Annual Estimate 260	Annual Estimate 260
Not intimate but in room of origin	2%	7%	17%	11%
Not in room of origin	9%	27%	18%	14%
Unclassified	--	55%	17%	23%
	--	--	--	--
<u>15 to 64 Years of Age</u>				
Victim Intimate with Ignition	Annual Estimate 220	Annual Estimate 220	Annual Estimate 1,560	Annual Estimate 1,560
Not intimate but in room of origin	12%	16%	10%	6%
Not in room of origin	16%	16%	18%	12%
Unclassified	5%	34%	25%	29%
	0%	--	0%	0%
<u>65 Years of Age and Older</u>				
Victim Intimate with Ignition	Annual Estimate 140	Annual Estimate 140	Annual Estimate 280	Annual Estimate 280
Not intimate but in room of origin	11%	15%	14%	6%
Not in room of origin	11%	30%	15%	11%
Unclassified	7%	26%	21%	32%
	--	--	--	--

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes  
 Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates from a survey conducted by the National Fire Protection Association (NFPA). Estimates are based on a 5-year average from 1994 through 1998.  
 Due to rounding, detail may not add to total.  
 Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration.

victims not intimate with ignition but in the room of origin where the flame extended beyond the room of origin are also likely to be affected by an open flame standard. For in-scope mattress/bedding fires, the percentages of deaths to young children below the age of 5 that are affected in these categories are 2% (less than 10 deaths/year) and 31% (30 deaths/year), respectively, and 14% (30 injuries/year) and 21% (50 injuries/year) for injuries. Thus, the total percentage of mattress/bedding fire deaths to young children that would be addressable by an open flame standard aimed at the prevention of flashover is 71% (60 deaths/year) and the percentage of injuries is 58% (130 injuries/year).

#### **IV. Investigations**

##### **A. First Item Ignited**

Of the 431 mattress and/or bedding fires investigated by CPSC field staff since 1994, a mattress was found to be the first item ignited in 92 of these cases (33% of cases in which the item first ignited was known). Bedding was reported as the first item ignited in 146 of the cases investigated (52% of cases in which the item first ignited was known). Whether the bedding or the mattress ignited first was unknown in 148 of the investigations. An electric blanket ignited first in 28 of the cases and a boxspring in 17 of the cases (10% and 6% of cases in which the item first ignited was known, respectively). As listed in Table 9, details regarding the specific type of bedclothes were often limited. When the type of bedding materials first ignited were identified, sheets were the most common item specified. The reader is cautioned about drawing conclusions about the relative distribution of the item first ignited because of the small sample size and the difficulty in identifying the ignition sequence. Another issue that must be highlighted is the preponderance of lighter child play fires due to the special study involving data collection on such fires from November 1997 to February 1999. As a result, fire investigations involving children playing with lighters dominated the mattress fire cases collected during that time period. It is also noted that the cases investigated were limited in number and were not from a national sample with a known selection probability.

##### **B. Location of Ignition**

Among the 92 fires in which the mattress was determined to be the first item ignited, the location of ignition was identified for 41 of these fires. As illustrated in Table 10, the top surface was the most frequently reported surface for ignition. Mattress fires caused by smoking materials began on the top surface, while the fires due to open flame and other ignition sources occurred in a variety of locations on the mattress.

##### **C. Age of Person Involved in Ignition**

A caution when interpreting the results on the age of the person involved in ignition: mattress fire investigations involving children playing with lighters are over-represented in the age distribution due to the data collection for the cigarette lighter study. Hence,

Table 9  
 First Item Ignited by Ignition Source  
 Sample Cases Collected October 1994 - August 2000

FIRST ITEM IGNITED	IGNITION SOURCE				
	Total	Smoking Material	Open Flame	Other	Unknown
<b>Total</b>	431	73	258	89	11
Unknown	148	26	100	19	3
Known	283	47	158	70	8
<b>Mattress</b>	92	17	47	20	8
<b>Bedding</b>	146	29	97	20	•
Bedsread	11	1	10	--	----
Blanket	11	1	8	2	----
Comforter	5	--	4	1	----
Dust Ruffle	7	3	4	--	----
Pad	2	--	2	--	----
Pillowcase	2	--	2	--	----
Sheets	21	7	9	5	----
Bedding Item, NS	87	17	58	12	----
<b>Electric Blanket/Pad</b>	28	--	--	28	----
<b>Boxspring</b>	17	1	14	2	----

Note: CPSC conducted data collection on lighter child play fires from November 1997 to February 1999. As a result, mattress fire investigations involving lighters may be over-represented.  
 Source: Investigations conducted by the U. S. Consumer Product Safety Commission October 1994 to August 2000.

Table 10  
 Location of Mattress Ignition by Ignition Source  
 Sample Cases Collected October 1994 - August 2000

LOCATION OF IGNITION	IGNITION SOURCE				
	Total	Smoking Material	Open Flame	Other	Unknown
Total	92	17	47	20	8
Unknown	51	10	22	12	7
Known	41	7	25	8	1
<u>Total Known</u>					
Top Surface	21	7	9	4	1
Side of Mattress	7	--	6	1	--
Underside of Mattress	13	--	10	3	--

Note: CPSC conducted data collection on lighter child play fires from November 1997 to February 1999. As a result, mattress fire investigations involving lighters may be over-represented.  
 Source: Investigations conducted by the U.S. Consumer Product Safety Commission October 1994 to August 2000.

although the overall age distribution is not accurately represented by the investigation data, information about the mechanisms involved in ignition within age groups is useful. The age of the person involved in ignition, e.g. the adult smoker or the child playing with a lighter, was identified in 345 fires (80%). As listed in Table 11, 241 of the cases in which age was known identified the age of the person involved in ignition as less than 15 years old (142 were less than 5 years old; 99 were 5-14 years of age). Child play was involved in 233 investigated fires in which the age of the child involved in ignition was known. Of these, 128 fires involved a child under age 5 playing with a lighter. For virtually all of the fires started by children less than 15 years of age, an adult did not witness the ignition of the mattress or bedding. When adults were involved, abandoned/discarded materials or falling asleep were the most common causes of mattress/bedding fires, accounting for 58 (56%) of the fires involving older adolescents and adults.

#### **D. Bedding present**

The total number of bedding items present during mattress/bedding fires was reported in about two-thirds of the investigations. Of these cases, about one-half reported that more than one bedding item was present. Less than 10% of the cases reported that no bedding items were involved in the mattress fire.

#### **V. Discussion**

The methodology used in this report for estimating mattress and bedding fire loss yields a conservative approach to describing the size of the fire problem that an open flame standard for mattresses may address. The following reasons lead to conservative estimates:

- First, the exclusion of incendiary and suspicious fire losses implies that none of these fires could be prevented by the standard.
- Second, the decision to exclude cases with apparently inconsistent coding on data elements other than form of material ignited (i.e. identified as mattress or bedding) assumes there is a coding error and the error is always in the coding of the form of material ignited and not in any of the other variables considered.
- Third, this editing process is one-sided, as it does not consider the possibility of miscodes where mattress or bedding fires may have been erroneously coded as something else.

The steps described earlier in this report for grouping mattress and bedding fire losses, editing the NFIRS database, and for allocation of unknowns were incorporated into this analysis. The methodology used in the 1998 Residential Fire Loss Estimates involved making national estimates for many product categories and therefore did not involve data editing. Also, different grouping strategies were employed. As a result, some differences exist between the estimates in these recently published CPSC documents.

Table 11  
Age of Person Involved in Ignition and Ignition Factor by Source of Ignition  
Sample Cases Collected October 1994 - August 2000

AGE AND IGNITION FACTOR	IGNITION SOURCE				
	Total	Smoking Material	Open Flame	Other	Unknown
<u>Total Known</u>	345	58	244	40	3
<u>&lt;5 years of age</u>	142	--	140	2	--
Child Play	142	--	140	2	--
<u>5-14 years of age</u>	99	--	88	8	3
Child Play	91	--	87	1	3
Electrical/Mechanical Failure	4	--	--	4	--
Material Too Close to Heat	3	--	--	3	--
Collision, Overturn, Knockdown	1	--	1	--	--
<u>15-24 years of age</u>	27	10	10	7	--
Abandoned/Discarded Material	9	5	3	1	--
Falling Asleep	6	4	2	--	--
Electrical/Mechanical Failure	3	--	--	3	--
Teen Play/Teen With	2	--	2	--	--
Material Too Close to Heat	2	--	--	2	--
Unattended	2	--	2	--	--
Misuse of Material Ignited	1	--	--	1	--
Person Impaired	1	1	--	--	--
Collision, Overturn, Knockdown	1	--	1	--	--
<u>25-64 years of age</u>	48	30	4	14	--
Abandoned/Discarded Materials	16	15	1	--	--
Falling Asleep	11	10	1	--	--
Electrical/Mechanical Failure	7	--	--	7	--
Material Too Close to Heat	5	--	--	5	--
Unconscious	3	3	--	--	--
Inadequate Control of Flame	2	--	2	--	--
Person Impaired	2	2	--	--	--
Other Misuse	1	--	--	1	--
Unattended	1	--	--	1	--
<u>65+ years of age</u>	29	18	2	9	--
Abandoned/Discarded Materials	9	9	--	--	--
Falling Asleep	7	6	1	--	--
Electrical/Mechanical Failure	5	--	--	5	--
Person Impaired	4	3	1	--	--
Material Too Close to Heat	4	--	--	4	--

Note: CPSC conducted data collection on lighter child play fires from November 1997 to February 1999. As a result, mattress fire investigations involving lighters may be over-represented.

Source: Investigations conducted by the U.S. Consumer Product Safety Commission October 1994 to August 2000.

In the 1998 Residential Fire Loss Estimates (released March 26, 2001), CPSC staff estimated that 18,900 fires, 410 deaths, 2,260 injuries, and \$255.4 million in property damage were associated with mattress and bedding in 1998. Corresponding 1998 mattress and bedding estimates in this report were 18,100 fires, 390 deaths, 2,160 injuries, and \$208.3 million in property damage.

In addition, trend data presented in this report as well as the 1998 Residential Fire Loss Estimates differ from data in all previous CPSC reports containing national fire estimates for mattresses and bedding. CPSC staff revised an existing methodology for calculating the national fire loss estimates. In this revised method, CPSC staff eliminated incendiary and suspicious fires, including arson fires (in order to reflect fire losses more likely to be addressable by CPSC actions.) Also, fires with unidentified product-specific codes within a known general product category (e.g. mattress or bedding) were re-allocated in order to eliminate "unknown" estimates at all levels. These two revisions enable better product-by-product comparisons and strengthen the staff's conclusions about product-related hazards.

After revising the overall methodology used to generate national fire estimates, CPSC developed an additional procedure to be used in regulatory analyses. The procedure involved editing the data in the NFIRS database. The NFIRS database was evaluated to categorize incidents that were likely to be addressed by an open flame standard for mattresses. Within the NFIRS data base, some incidents were re-categorized from "mattress" or "bedding" to "not mattress or bedding" when it was believed that, because of inconsistencies in the reported area of fire origin and type of material ignited, a mattress or bedding item may not have been the first item ignited.

# Appendix A

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**Table 1A**  
**U. S. Fire Administration's National Fire Incident Reporting System**  
**Residential Structure Fires and Civilian Death and Injury Case Counts and Total**  
**Property Loss Reported**

<b>Year</b>	<b>Fires</b>	<b>Deaths</b>	<b>Injuries</b>	<b>Property Loss In Millions</b>
1980	130,301	1,127	5,410	\$696.9
1981	156,314	1,272	6,582	\$829.0
1982	179,342	1,535	7,415	\$1,179.7
1983	202,597	1,656	8,554	\$1,243.1
1984	216,645	1,850	9,172	\$1,420.4
1985	235,333	1,887	9,949	\$1,701.7
1986	220,049	2,018	10,059	\$1,577.9
1987	223,906	1,906	10,292	\$1,961.3
1988	228,497	1,905	10,471	\$1,935.6
1989	218,310	1,860	10,262	\$1,909.2
1990	212,007	1,838	10,372	\$1,996.8
1991	216,979	1,778	10,807	\$2,043.7
1992	210,470	1,734	11,290	\$2,197.3
1993	209,411	1,630	10,806	\$2,194.9
1994	198,298	1,748	10,413	\$1,945.5
1995	185,802	1,453	9,638	\$1,915.2
1996	191,729	1,503	9,401	\$2,110.5
1997	157,137	1,156	7,508	\$1,750.8
1998	156,661	1,229	7,379	\$1,836.6

Source: U. S. Fire Administration's National Fire Incident Reporting System, 1980 - 1998.

**Table 2A**  
**National Fire Protection Association's Annual Estimates for**  
**Residential Structure Fires, Civilian Deaths and Injuries, and Property Loss**

<b>Year</b>	<b>Fires</b>	<b>Deaths</b>	<b>Injuries</b>	<b>Property Loss In Millions</b>
1980	757,500	5,446	21,100	\$3,042
1981	733,000	5,540	20,375	\$3,259
1982	676,500	4,940	21,100	\$3,253
1983	641,500	4,820	21,450	\$3,306
1984	623,000	4,240	19,275	\$3,440
1985	622,000	5,025	19,825	\$3,774
1986	581,500	4,770	19,025	\$3,556
1987	551,500	4,660	20,440	\$3,699
1988	552,500	5,065	22,600	\$4,020
1989	513,500	4,435	20,750	\$3,998
1990	467,000	4,115	20,650	\$4,253
1991	478,000	3,575	21,850	\$5,552
1992	472,000	3,765	21,600	\$3,880
1993	470,000	3,825	22,600	\$4,843
1994	451,000	3,465	20,025	\$4,317
1995	425,500	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

Source: National Fire Protection Association's annual survey of fire departments, 1980 – 1998.

## Appendix B

.

**Table 1B  
NFPA 901 Standard Codes Used in Mattress and Bedding Fire Loss Estimates**

<b>Form of Heat of Ignition</b>	<b>NFPA 901 Standard Codes</b>
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 Ignition 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) 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)

	<p>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)          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)          00, missing codes, and blanks</p>
<p><b>Out-of-Scope Ignition Sources</b></p>	
<p><b>Unknown Ignition Sources</b></p> <p><b>Form of Material First Ignited</b>          Mattress, pillow          Bedding, blanket, sheet, comforter          Not Mattress/Bedding          Unknown Form of Material Ignited</p>	<p>31          32          All codes except 31, 32, and unknown form of material ignited          00, missing codes, and blanks, 30 (Unknown Soft Goods)</p>

**Table 2B  
Mattress and Bedding Fire Loss Editing Procedure**

<b>Variable</b>	<b>Traditional Small Open Flame(Candles, Matches, Lighters) and Smoking Material Ignition Sources</b>	<b>Mattress/Bedding – In-scope</b>	<b>Mattress/Bedding – Not Addressable</b>	<b>Not Mattress/Bedding</b>
<b>Type of Material First Ignited</b>	<p>Plastic (40- 49)                      Natural Product, insufficient information to classify further (50)                      Rubber (51)                      Leather (53)                      Grain, natural fiber (pre-process) (55)                      Included are leathers, felt, kapok, hessian, hemp, sisal, jute, cocofilm, flax, and cotton.                      Natural Product not classified above (59)                      Wood, Paper, insufficient information to classify further (60)                      Sawm 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)                      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)                      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)</p>	<p>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)</p>		<p>Escalator (04)                      Utility shaft (52)                      Light shaft (53)                      Chute (54)                      Duct (55)</p>
<b>Area of Origin</b>				

<p><b>Ignition Factor</b></p>	<p>Service, Equipment Areas (60- 69)  Structural Areas (71-77, 79)  Other Area of Origin (91- 99)  Missing data codes (00, ??, blanks)  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 Deficiency (60-64, 69)  Operational Deficiency (70-73, 75-79)  Other Ignition Factor (90- 91, 99)  Missing data codes (00, ??, blanks)</p>	<p>Cutting, welding too close (35)  Fuel spilled, released accidentally (41)  Improper fueling technique (42)  Flammable liquid used to kindle fire (43)  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)  All other codes</p>	<p>Chimney (57)  Conveyer (58)  Awning (78)  Transportation, Vehicle Areas (80- 89)</p>
<p><b>Equipment Involved in Ignition</b></p>	<p>Other object, insufficient information to classify further (90)  No equipment involved (98)  Other object not classified above (99)  Missing data codes (00, ??, blanks)</p>		

**Table 2B (Continued)**  
**Mattress and Bedding Fire Loss Editing Procedure**  
**Additional Small Open Flame Sources and Other In-scope Ignition Sources**

<b>Variable</b>	<b>Mattress/Bedding – In-scope</b>	<b>Mattress/Bedding – Not Addressable</b>	<b>Not Mattress/Bedding</b>
<b>Type of Material First Ignited</b>	<p>Plastic (40- 49)                      Natural Product, insufficient information to classify further (50)                      Rubber (51)                      Leather (53)                      Grain, natural fiber (pre- process) (55)                      Included are leathers, felt, kapok, hessian, hemp, sisal, jute, cocofilm, flax, and cotton.                      Natural Product not classified above (59)                      Wood, Paper; insufficient information to classify further (60)                      Sawm 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)                      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)                      Means of Egress (01- 03, 05- 09)                      Assembly, Sales Areas (11- 19)                      Function Areas (21 – 39)                      Storage Areas (41 – 49)</p>		<p>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)</p>
<b>Area of Origin</b>			<p>Escalator (04)                      Utility shaft (52)                      Light shaft (53)                      Chute (54)</p>

<p><b>Ignition Factor</b></p>	<p>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)  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)</p>	<p>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)  Processing Equipment (70-79)  Service, Maintenance Equipment (80-86, 89)  Other Object, Exposure Fire (91-96)</p>	<p>Duct (55)  Chimney (57)  Conveyer (58)  Awning (78)  Transportation, Vehicle Areas (80- 89)</p>
<p><b>Equipment Involved in Ignition</b></p>	<p>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)</p>		

**Table 2B (Continued)**  
**Mattress and Bedding Fire Loss Editing Procedure**  
**Out-of-Scope or Unknown Forms of Heat of Ignition**

<b>Variable</b>	<b>Mattress/Bedding – In-scope</b>	<b>Mattress/Bedding – Not Addressable</b>	<b>Not Mattress/Bedding</b>
<b>Type of Material First Ignited</b>	<p>Plastic (40- 49)                      Natural Product, insufficient information to classify further (50)                      Rubber (51)                      Leather (53)                      Grain, natural fiber (pre- process) (55)                      Included are leathers, felt, kapok, hessian, hemp, sisal, jute, cocofilm, flax, and cotton.                      Natural Product not classified above (59)                      Wood, Paper; insufficient information to classify further (60)                      Sawm 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)                      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)                      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)</p>		<p>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)</p>
<b>Area of Origin</b>			<p>Escalator (04)                      Utility shaft (52)                      Light shaft (53)                      Chute (54)                      Duct (55)</p>

	Service, Equipment Areas (60-69) Structural Areas (71-77, 79) Other Area of Origin (91-99) Missing data codes (00, ??, blanks) All codes		Chimney (57) Conveyor (58) Awning (78) Transportation, Vehicle Areas (80-89)
<b>Ignition Factor Equipment Involved in Ignition</b>	<b>All codes</b>		

## Appendix C

.

Table 1C  
National Estimates of Residential Fires, Civilian Casualties, and Property Loss  
Associated With In-Scope Mattress Fires by Ignition Source 1980 - 1998

	YEAR									
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
<u>Total In-Scope Mattress</u>	300	300	280	320	240	300	270	260	330	210
Smoking Material	210	200	220	270	170	210	180	170	190	130
Candles, Matches, Lighters	40	60	30	20	30	50	40	40	70	60
Additional Small Open Flame Source	--	--	10	10	10	--	--	10	--	10
Other In-Scope Ignition Sources	50	40	30	30	40	40	40	30	70	10
	FIRE DEATHS									
<u>Total In-Scope Mattress</u>	1,420	1,340	1,500	1,490	1,400	1,370	1,250	1,540	1,460	1,330
Smoking Material	930	860	890	890	790	760	710	770	810	620
Candles, Matches, Lighters	310	300	380	400	390	420	340	450	420	460
Additional Small Open Flame Source	**	10	10	20	10	20	10	20	20	30
Other In-Scope Ignition Sources	180	170	220	180	210	170	200	300	220	210
	FIRE INJURIES									
<u>Total In-Scope Mattress</u>	36,200	30,400	25,800	23,200	21,700	21,300	19,900	18,600	17,600	16,000
Smoking Material	20,400	17,100	14,000	12,000	11,300	11,000	10,200	9,400	8,600	7,600
Candles, Matches, Lighters	9,600	8,100	6,700	6,600	6,100	6,100	5,600	5,400	5,300	5,000
Additional Small Open Flame Source	400	400	300	400	300	300	300	300	300	300
Other In-Scope Ignition Sources	5,800	4,900	4,900	4,300	4,000	3,800	3,700	3,500	3,400	3,000
	PROPERTY LOSS (MILLIONS)									
<u>Total In-Scope Mattress</u>	\$145.6	\$135.2	\$124.1	\$119.8	\$120.0	\$129.2	\$121.7	\$123.8	\$127.9	\$124.4
Smoking Material	\$82.1	\$76.1	\$67.2	\$61.9	\$62.5	\$66.7	\$62.6	\$62.3	\$62.4	\$59.3
Candles, Matches, Lighters	\$38.6	\$35.8	\$32.0	\$33.8	\$33.6	\$37.2	\$34.5	\$36.0	\$38.4	\$39.2
Additional Small Open Flame Source	\$1.8	\$1.6	\$1.4	\$1.8	\$1.7	\$2.0	\$2.0	\$2.3	\$2.2	\$2.7
Other In-Scope Ignition Sources	\$23.1	\$21.6	\$23.4	\$22.2	\$22.2	\$23.3	\$22.6	\$23.2	\$24.9	\$23.2

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes. Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA). Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (-) indicates that no NFIRS reports were received. Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration



Table 2C  
National Estimates of Residential Fires, Civilian Casualties, and Property Loss  
Associated With In-Scope Bedding Fires by Ignition Source 1980 - 1988

	YEAR									
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
<b>Total In-Scope Bedding</b>	530	530	410	300	390	520	390	430	520	340
Smoking Material	280	390	260	180	200	280	190	220	260	180
Candles, Matches, Lighters	110	60	80	60	90	130	80	120	150	70
Additional Small Open Flame Source	--	--	10	10	10	10	--	--	10	--
Other In-Scope Ignition Sources	140	90	70	60	90	100	120	90	90	90
	FIRE DEATHS									
<b>Total In-Scope Bedding</b>	1,520	1,340	1,280	1,410	1,380	1,320	1,280	1,500	1,550	1,490
Smoking Material	620	580	440	550	490	450	440	500	510	440
Candles, Matches, Lighters	460	370	460	410	490	460	470	650	630	530
Additional Small Open Flame Source	10	20	10	30	**	30	20	20	20	20
Other In-Scope Ignition Sources	420	370	360	430	390	380	350	330	390	490
	FIRE INJURIES									
<b>Total In-Scope Bedding</b>	20,800	18,100	15,500	15,300	15,400	15,400	14,500	13,400	13,500	12,500
Smoking Material	7,100	6,000	4,500	4,700	4,700	4,700	4,500	3,900	4,000	3,600
Candles, Matches, Lighters	5,700	4,800	4,500	4,300	4,500	4,600	4,700	4,500	4,500	4,100
Additional Small Open Flame Source	300	300	200	200	200	300	300	300	300	200
Other In-Scope Ignition Sources	7,700	7,000	6,300	6,000	6,000	5,700	5,100	4,800	4,800	4,600
	FIRES									
<b>Total In-Scope Bedding</b>	\$83.5	\$80.5	\$74.5	\$79.0	\$85.3	\$93.4	\$88.9	\$89.3	\$98.5	\$97.3
Smoking Material	\$28.5	\$26.7	\$21.7	\$24.4	\$25.9	\$28.7	\$27.3	\$26.3	\$28.9	\$27.9
Candles, Matches, Lighters	\$22.9	\$21.4	\$21.5	\$22.3	\$25.1	\$27.9	\$28.7	\$29.7	\$32.7	\$31.9
Additional Small Open Flame Source	\$1.2	\$1.3	\$1.1	\$1.3	\$1.3	\$1.9	\$1.6	\$1.8	\$2.1	\$1.8
Other In-Scope Ignition Sources	\$31.0	\$31.1	\$30.2	\$31.0	\$32.9	\$34.8	\$31.3	\$31.6	\$34.8	\$35.8
	PROPERTY LOSS (MILLIONS)									

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes.  
 Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA).  
 Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (--) indicates that no NFIRS reports were received.  
 Source: U.S. Consumer Product Safety Commission; data obtained from the National Fire Protection Association and the U.S. Fire Administration

Table 2C  
National Estimates of Residential Fires, Civilian Casualties, and Property Loss  
Associated With In-Scope Bedding Fires by Ignition Source 1980 - 1998

	YEAR									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	
<b>Total In-Scope Bedding</b>	350	390	370	380	270	330	320	260	260	
Smoking Material	180	140	180	210	110	160	120	90	120	
Candles, Matches, Lighters	100	130	120	130	110	100	60	60	70	
Additional Small Open Flame Source	10	10	**	--	--	10	30	20	10	
Other In-Scope Ignition Sources	60	100	60	40	50	70	110	80	60	
				<b>FIRE DEATHS</b>						
<b>Total In-Scope Bedding</b>	1,400	1,400	1,620	1,590	1,400	1,240	1,330	1,210	1,260	
Smoking Material	450	360	400	430	310	290	330	340	280	
Candles, Matches, Lighters	570	620	810	680	730	640	640	480	630	
Additional Small Open Flame Source	10	20	30	40	20	30	40	40	20	
Other In-Scope Ignition Sources	380	400	380	440	340	270	320	340	320	
				<b>FIRE INJURIES</b>						
<b>Total In-Scope Bedding</b>	11,200	11,400	11,700	11,500	11,500	9,700	10,000	9,200	8,700	
Smoking Material	3,100	2,800	3,000	2,500	2,500	2,100	2,200	2,000	2,000	
Candles, Matches, Lighters	3,800	4,300	4,600	4,600	5,000	3,900	3,900	3,300	3,400	
Additional Small Open Flame Source	200	200	300	200	300	200	300	200	200	
Other In-Scope Ignition Sources	4,100	4,100	3,800	4,100	3,800	3,500	3,600	3,700	3,200	
				<b>FIRES</b>						
<b>Total In-Scope Bedding</b>	\$102.2	\$132.0	\$96.1	\$118.4	\$109.8	\$99.0	\$116.2	\$104.2	\$100.3	
Smoking Material	\$27.8	\$32.4	\$24.6	\$26.0	\$23.5	\$21.6	\$25.5	\$22.6	\$22.9	
Candles, Matches, Lighters	\$35.1	\$49.4	\$37.8	\$47.8	\$47.5	\$39.6	\$45.8	\$37.2	\$39.2	
Additional Small Open Flame Source	\$2.2	\$2.9	\$2.2	\$2.0	\$2.5	\$2.4	\$3.1	\$2.4	\$2.0	
Other In-Scope Ignition Sources	\$37.1	\$47.4	\$31.6	\$42.7	\$36.2	\$35.4	\$41.8	\$42.0	\$36.3	
				<b>PROPERTY LOSS (MILLIONS)</b>						

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes. Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA). Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (-) indicates that no NFIRS reports were received. Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration.

Table 3C  
 Percent Change in National Estimates of Residential Fires, Civilian Casualties, and Property Loss  
 Associated With In-Scope Mattress Fires, Comparing 1980 and 1998

	1980	1998	% Change
	<b>FIRE DEATHS</b>		
<b>Total Residential Fire Deaths</b>	5,446	3,250	-40%
Total In-Scope Mattress Fire Deaths	300	130	-57%
Smoking Material	210	110	-48%
All Small Open Flame Sources	40	10	-75%
Other In-Scope Ignition Sources	50	10	-80%
	<b>FIRE INJURIES</b>		
<b>Total Residential Fire Injuries</b>	21,100	17,175	-19%
Total In-Scope Mattress Fire Injuries	1,420	830	-42%
Smoking Material	930	370	-60%
All Small Open Flame Sources	310	330	6%
Other In-Scope Ignition Sources	180	130	-28%
	<b>FIRES</b>		
<b>Total Residential Fires</b>	757,500	381,500	-50%
Total In-Scope Mattress Fires	36,200	8,600	-76%
Smoking Material	20,400	3,300	-84%
All Small Open Flame Sources	10,100	3,100	-69%
Other In-Scope Ignition Sources	5,800	2,100	-64%
	<b>PROPERTY LOSS (MILLIONS)</b>		
<b>Total Residential Fire Property Loss</b>	\$3,042.0	\$4,391.0	44%
Total In-Scope Mattress Property Loss	\$145.6	\$98.8	-32%
Smoking Material	\$82.1	\$38.5	-53%
All Small Open Flame Sources	\$40.4	\$36.2	-10%
Other In-Scope Ignition Sources	\$23.1	\$24.1	4%

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes.

Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA).

Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (-) indicates that no NFIRS reports were received.

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

Table 4C

Percent Change in National Estimates of Residential Fires, Civilian Casualties, and Property Loss Associated With In-Scope Bedding Fires, Comparing 1980 and 1998

	1980	1998	% Change
<b>FIRE DEATHS</b>			
<u>Total Residential Fire Deaths</u>	5,446	3,250	-40%
Total In-Scope Bedding Fire Deaths	530	260	-51%
Smoking Material	280	120	-57%
All Small Open Flame Sources	110	80	-27%
Other In-Scope Ignition Sources	140	60	-57%
<b>FIRE INJURIES</b>			
<u>Total Residential Fire Injuries</u>	21,100	17,175	-19%
Total In-Scope Bedding Fire Injuries	1,520	1,260	-17%
Smoking Material	620	280	-55%
All Small Open Flame Sources	480	650	35%
Other In-Scope Ignition Sources	420	320	-24%
<b>FIRES</b>			
<u>Total Residential Fires</u>	757,500	381,500	-50%
Total In-Scope Bedding Fires	20,800	8,700	-58%
Smoking Material	7,100	2,000	-72%
All Small Open Flame Sources	6,000	3,600	-40%
Other In-Scope Ignition Sources	7,700	3,200	-58%
<b>PROPERTY LOSS (MILLIONS)</b>			
<u>Total Residential Fire Property Loss</u>	\$3,042.0	\$4,391.0	44%
Total In-Scope Bedding Property Loss	\$83.5	\$100.3	20%
Smoking Material	\$28.5	\$22.9	-20%
All Small Open Flame Sources	\$24.0	\$41.2	72%
Other In-Scope Ignition Sources	\$31.0	\$36.3	17%

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes.

Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA).

Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (-) indicates that no NFIRS reports were received.

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

Table 5C  
 Percentage of Civilian Casualties Associated With In-Scope Mattress Fires  
 Victim Location by Extent of Flame Damage 1994 - 1998

	Deaths		Injuries	
	Flame Confined to Room of Origin	Flame Beyond Room of Origin	Flame Confined to Room of Origin	Flame Beyond Room of Origin
<b>All In-Scope Mattress Fires</b>				
Victim Intimate with Ignition	12%	12%	14%	6%
Not intimate but in room of origin	17%	16%	19%	11%
Not in room of origin	6%	37%	25%	24%
Unclassified	--	--	0%	0%
	<i>Annual Estimate 200</i>		<i>Annual Estimate 1,030</i>	
<b>Smoking Material</b>				
Victim Intimate with Ignition	16%	16%	18%	7%
Not intimate but in room of origin	16%	16%	19%	9%
Not in room of origin	7%	29%	23%	23%
Unclassified	--	--	1%	1%
	<i>Annual Estimate 120</i>		<i>Annual Estimate 420</i>	
<b>All Small Open Flame Sources</b>				
Victim Intimate with Ignition	5%	--	13%	4%
Not intimate but in room of origin	16%	22%	19%	13%
Not in room of origin	8%	50%	27%	24%
Unclassified	--	--	0%	--
	<i>Annual Estimate 50</i>		<i>Annual Estimate 460</i>	
<b>Other In-Scope Ignition Sources</b>				
Victim Intimate with Ignition	2%	13%	8%	8%
Not intimate but in room of origin	25%	5%	21%	11%
Not in room of origin	--	55%	26%	26%
Unclassified	--	--	--	--
	<i>Annual Estimate 30</i>		<i>Annual Estimate 160</i>	

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes  
 Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates from a survey conducted by the National Fire Protection Association (NFPA). Estimates are based on a 5-year average from 1994 through 1998.  
 Due to rounding, detail may not add to total.  
 Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration

Table 6C  
 Percentage of Civilian Casualties Associated With In-Scope Bedding Fires  
 Victim Location by Extent of Flame Damage 1994 - 1998

	Deaths		Injuries	
	Flame Confined to Room of Origin	Flame Beyond Room of Origin	Flame Confined to Room of Origin	Flame Beyond Room of Origin
<b>All In-Scope Bedding Fires</b>				
Victim Intimate with Ignition	9%	16%	10%	8%
Not intimate but in room of origin	10%	29%	16%	14%
Not in room of origin	4%	32%	20%	32%
Unclassified	0%	--	0%	0%
	Annual Estimate 290		Annual Estimate 1,290	
<b>Smoking Material</b>				
Victim Intimate with Ignition	11%	22%	15%	14%
Not intimate but in room of origin	16%	21%	16%	17%
Not in room of origin	5%	25%	10%	27%
Unclassified	1%	--	0%	0%
	Annual Estimate 120		Annual Estimate 310	
<b>All Small Open Flame Sources</b>				
Victim Intimate with Ignition	9%	16%	9%	6%
Not intimate but in room of origin	10%	28%	14%	13%
Not in room of origin	1%	35%	25%	34%
Unclassified	--	--	0%	0%
	Annual Estimate 90		Annual Estimate 650	
<b>Other In-Scope Ignition Sources</b>				
Victim Intimate with Ignition	6%	6%	8%	7%
Not intimate but in room of origin	--	43%	19%	13%
Not in room of origin	6%	40%	21%	32%
Unclassified	--	--	--	--
	Annual Estimate 70		Annual Estimate 320	

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes.  
 Estimates were derived by applying proportions observed in national fire incident data (NF-IRS), obtained from the U.S. Fire Administration, to aggregate national estimates from a survey conducted by the National Fire Protection Association (NFPA). Estimates are based on a 5-year average from 1994 through 1998.  
 Due to rounding, detail may not add to total.  
 Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration

Table 7C  
National Estimates of Civilian Casualties Associated With In-Scope Mattress Fires  
by Age Group 1994 - 1998

	AGE				
	Total	Under 5	5 to 14	15 to 64	65 and Older
<b>Total In-Scope Mattress Fire Deaths</b>			DEATHS		
Smoking Material	200	40	10	110	40
Candles, Matches, Lighters	120	10	**	80	30
Additional Small Open Flame Sources	40	30	10	10	--
Other In-Scope Ignition Sources	**	**	--	**	--
	30	**	**	20	10
<b>Total In-Scope Mattress Fire Injuries</b>			INJURIES		
Smoking Material	1,030	90	110	710	120
Candles, Matches, Lighters	420	10	20	320	70
Additional Small Open Flame Sources	450	80	70	270	30
Other In-Scope Ignition Sources	10	--	--	10	--
	160	10	20	110	20

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes. Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA). Estimates are based on a 5 year average from 1994 through 1998. Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (-) indicates that no NFIRS reports were received. Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration

Table 8C  
National Estimates of Civilian Casualties Associated With In-Scope Bedding Fires  
by Age Group 1994 - 1998

	Total	AGE			
		Under 5	5 to 14	15 to 64	65 and Older
<u>Total In-Scope Bedding Fire Deaths</u>	290	50	20	120	90
Smoking Material	120	**	**	70	40
Candles, Matches, Lighters	80	50	10	20	10
Additional Small Open Flame Sources	10	**	**	**	10
Other In-Scope Ignition Sources	70	10	10	20	30
			DEATHS		
<u>Total In-Scope Bedding Fire Injuries</u>	1,290	130	160	840	160
Smoking Material	310	**	10	240	60
Candles, Matches, Lighters	620	110	100	380	30
Additional Small Open Flame Sources	30	**	10	20	**
Other In-Scope Ignition Sources	320	20	40	200	60
			INJURIES		

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes. Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates conducted by the National Fire Protection Association (NFPA). Estimates are based on a 5-year average from 1994 through 1998. Due to rounding, column detail may not add to total. Fire estimates are rounded to the nearest 100, deaths and injuries to the nearest 10, property loss to the nearest tenth of a million. Fire estimates less than 100 are denoted by an asterisk (\*), death and injury estimates less than 10 by a double asterisk (\*\*). A value of (-) indicates that no NFIRS reports were received. Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration.

Table 9C  
 Percentage of Civilian Casualties Associated With In-Scope Mattress Fires for Particular Age Groups  
 Victim Location by Extent of Flame Damage 1994 - 1998

	Deaths		Injuries	
	Flame Confined to Room of Origin	Flame Beyond Room of Origin	Flame Confined to Room of Origin	Flame Beyond Room of Origin
	Annual Estimate	Annual Estimate	Annual Estimate	Annual Estimate
<u>Under 5 Years of Age</u>				
Victim Intimate with Ignition	2%	3%	22%	13%
Not intimate but in room of origin	17%	23%	13%	15%
Not in room of origin	3%	52%	16%	20%
Unclassified	--	--	--	1%
<u>5 to 14 Years of Age</u>				
Victim Intimate with Ignition	--	--	19%	7%
Not intimate but in room of origin	9%	11%	17%	20%
Not in room of origin	--	80%	18%	19%
Unclassified	--	--	--	--
<u>15 to 64 Years of Age</u>				
Victim Intimate with Ignition	16%	14%	12%	5%
Not intimate but in room of origin	19%	14%	21%	10%
Not in room of origin	6%	32%	27%	24%
Unclassified	--	--	1%	0%
<u>65 Years of Age and Older</u>				
Victim Intimate with Ignition	13%	18%	16%	4%
Not intimate but in room of origin	13%	15%	16%	7%
Not in room of origin	13%	28%	25%	32%
Unclassified	--	--	--	--

Notes Smoking materials are cigarettes (primarily), cigars, and pipes.  
 Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates from a survey conducted by the National Fire Protection Association (NFPA). Estimates are based on a 5-year average from 1994 through 1998.  
 Due to rounding, detail may not add to total  
 Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration.

Table 10C  
 Percentage of Civilian Casualties Associated With In-Scope Bedding Fires for Particular Age Groups  
 Victim Location by Extent of Flame Damage 1994 - 1998

	Deaths		Injuries	
	Flame Confined to Room of Origin	Flame Beyond Room of Origin	Flame Confined to Room of Origin	Flame Beyond Room of Origin
<u>Under 5 Years of Age</u>	<i>Annual Estimate 50</i>			
Victim Intimate with Ignition	12%	18%	12%	13%
Not intimate but in room of origin	4%	36%	12%	25%
Not in room of origin	1%	29%	13%	26%
Unclassified	--	--	--	--
<u>5 to 14 Years of Age</u>	<i>Annual Estimate 20</i>			
Victim Intimate with Ignition	2%	10%	16%	14%
Not intimate but in room of origin	9%	34%	19%	10%
Not in room of origin	--	45%	16%	25%
Unclassified	--	--	--	--
<u>15 to 64 Years of Age</u>	<i>Annual Estimate 120</i>			
Victim Intimate with Ignition	9%	18%	8%	6%
Not intimate but in room of origin	13%	17%	16%	13%
Not in room of origin	5%	36%	22%	34%
Unclassified	1%	--	0%	0%
<u>65 Years of Age and Older</u>	<i>Annual Estimate 90</i>			
Victim Intimate with Ignition	9%	13%	13%	8%
Not intimate but in room of origin	10%	38%	15%	14%
Not in room of origin	5%	26%	18%	33%
Unclassified	--	--	--	--

Notes: Smoking materials are cigarettes (primarily), cigars, and pipes.  
 Estimates were derived by applying proportions observed in national fire incident data (NFIRS), obtained from the U.S. Fire Administration, to aggregate national estimates from a survey conducted by the National Fire Protection Association (NFPA). Estimates are based on a 5-year average from 1994 through 1998.  
 Due to rounding, detail may not add to total.  
 Source: U.S. Consumer Product Safety Commission, data obtained from the National Fire Protection Association and the U.S. Fire Administration.

## Endnotes

1. Mah, J. (2001). 1998 Residential Fire Loss Estimates. Consumer Product Safety Commission, Directorate for Epidemiology, Washington, DC 20207.
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# Tab C



UNITED STATES  
CONSUMER PRODUCT SAFETY COMMISSION  
WASHINGTON, DC 20207

**Memorandum**

Date: June 15, 2001

TO : Margaret L. Neily, ES  
THROUGH: Warren J. Prunella, Associate Executive Director For Economic Analysis *WJP*  
FROM : Terrance R. Karels, EC *TRK*  
SUBJECT : Mattress Petitions

The Commission has received four petitions from the Children's Coalition for Fire Safety, requesting various changes to existing regulations for mattresses. The changes range from revisions to labeling requirements to changes in fire retardancy for these products. This memo provides some market information for use in the Commission's consideration of these petitions. The market information provides data on mattresses, but does not include futons, waterbed or airbed systems, or sofa beds, none of which are subjects of the petitions.

The International Sleep Products Association (ISPA), Alexandria, VA, is a trade group representing about 725 wholesalers, retailers, and manufacturers of conventional mattresses and foundations. According to the association, members account for over 80% of total US sales of these products.

**SHIPMENTS**

The ISPA estimated that, in total, about 38 million mattresses and foundations were shipped in the US in 1999. Of these, about 21 million units -- or 55% of shipments -- were mattresses. Mattresses account for more than 1/2 of shipments of mattresses and foundations because some mattresses are sold separately for use on frames that do not require foundations (such as platform beds or bunk beds) or as replacements for unserviceable mattresses. The ISPA reports annual shipments of mattresses over the past 10 years, as follows:

1990	16.2 million
1991	16.2 million
1992	16.9 million
1993	17.6 million
1994	18.2 million
1995	18.4 million
1996	18.6 million
1997	19.4 million
1998	20.1 million
1999	21.0 million

Based on these shipment statistics, the market for mattresses has been growing at a rate of about 3% per year in recent years. According to the ISPA, twin and double sizes account for over one-half of all shipments. Queen, king and custom sizes represent the remainder of shipments. In 1994, over 60% were of standard thickness (less than 9 inches). In recent years, however, there has been increased interest in “high contour” (also known as “pillow top”) or custom-sized bedding.

The ISPA reported that, in 1999, the average retail price of mattresses was \$134. Thus, the retail value of mattresses may have been about \$2.8 billion in 1999.

## **INTERNATIONAL TRADE**

There is little foreign trade in these products, reportedly because of the relatively high cost (as a share of price) of transporting these rather bulky items. While the retail value of US shipments of mattresses was about \$2.8 billion in 1999, the *US Department of Commerce* reported the customs value of imports of mattresses and foundations at about \$55 million. Similarly, exports of these products are reportedly small, about \$44 million in 1999. Thus, domestic production accounts for virtually all mattresses in use.

## NUMBER IN USE

The expected useful life of mattresses can vary substantially, with more expensive models generally experiencing the longest useful life. Industry sources recommend replacement of mattresses after 10 to 12 years of use, but did not estimate the average life expectancy of these products. An earlier EC market study estimated the expected useful life of mattresses at 14 years, based on earlier internal studies of the product as well as collateral work conducted by Battelle Columbus Laboratories.<sup>1</sup>

To estimate the number of mattresses in use, EC used the Commission's Product Population Model<sup>2</sup>. This model is a computer algorithm that estimates the number of units in use based on certain information. The information necessary for the calculation include the expected useful life of mattresses, a statistical distribution that describes the rate at which the product is retired from use, and historical sales data. For this computation, we used the 14 year expected useful life estimate, assumed the product failure rate could follow a gamma distribution, and used the annual shipment data obtained from the ISPA. Based on this information, there were an estimated 240 million mattresses in use at the end of 1999; this includes use in residences as well as commercial and institutional applications. The estimate is sensitive to changes in the assumptions used. For instance, if the ISPA's suggested replacement period (12 years) is used for the average expected useful life, the estimated number of mattresses in use would fall by about 12%, to 213 million at the end of 1999.

## PRODUCERS

The ISPA estimates that the top four producers, Sealy, Serta, Simmons, and Spring Air, operate about one-half of the 800 production facilities in the US. These four producers are also estimated to account for over 50% of total US production of mattresses. The remainder of the production facilities are operated by smaller manufacturers that tend to be family-owned firms supplying mattresses and foundations to a regional market. Production is concentrated in the

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<sup>1</sup> **Market Facts Regarding Conventional Bedding**, Anthony C. Homan, May 16, 1996

<sup>2</sup> Derived from **Product Life Model Feasibility and Development Study**, Battelle Columbus Laboratories, 1980

South (with about 40% of total US production), with the remainder spread throughout the Northeast, North Central, and Western states. *The US Bureau of the Census* reported that there are more than 250,000 workers in the US involved in the manufacture of mattresses.

The association also noted that there is a large (but unknown) number of mattress remanufacturers or renovators, who incorporate existing mattress covers and components with new padding and ticking to sell as reconditioned mattresses. Usually, this renovation involves consumers supplying an existing mattress to the firm, who then re-stuffs it with new foam padding. While the number of firms supplying this service is unknown, industry sources indicate that in some parts of the US such renovations account for as much as 25% of mattresses in use. The extent of such renovated mattresses in use is unknown and, thus, the total number of mattresses in use may be underestimated.

## **RETAILERS**

According to *Furniture Today* (July 24, 2000), the top 24 retailers accounted for about 40% of all US sales of beds (mattresses and foundations) in 1999; this is an increase from 1996, when the top 25 retailers accounted for 32% of sales. The top 4 retailers (in order of sales) in 1999 were Select Comfort, Mattress Discounters, Federated Stores, and Helig-Meyers. Together, these firms accounted for about 13% of the market.

Select Comfort, the leading retailer of beds in 1999, specializes in airbed systems that are not a subject of the petitions. It has 341 bedding specialty stores (2.5 times the number it had in 1996). It also uses direct marketing, offering its products on television (infomercials) and in national magazines and newspapers. The second leading retailer, Mattress Discounters, is also a chain of bed specialty stores. The third largest retailer is Federated Department Stores, the largest department store group in the US.

Helig-Meyers is the largest chain of furniture stores in the US. In August 2000, the firm filed for reorganization under Chapter 11 of the bankruptcy codes, and announced that it would close about 1/3 of its 871 retail outlets in the US. It intends to close all of its 81 stores in

California; the bulk of closings will be in the Southeast. The filing is the third top-100 furniture chain to file for bankruptcy protection this year.

A 1995 survey conducted by *Home Furnishings Executive*, a trade publication, found that over 80% of all beds are purchased by women. The survey also found that the age group with the largest share of sales was 30-44, with 44% of all bed purchases.

## **INSTITUTIONAL MATTRESSES**

In addition to mattresses sold for residential use, mattresses are also produced for institutional or commercial use. Institutional users include hospitals, military housing, and correctional facilities, while commercial users are most typically hotels and motels.

In 1999, sales of mattresses for institutional and commercial use totaled about \$268 million, according to the ISPA. While the average price of nonresidential mattresses is not available, an industry spokesperson projected that institutional and commercial mattresses would be similar in price to residential mattresses. If the average retail price of mattresses is used (\$134), some 2 million mattresses would have been shipped to institutional and commercial users in 1999.

## **AVAILABILITY OF MATTRESSES TESTED TO TB 129**

Some of the mattresses destined for use in institutional and commercial applications are tested to California's TB 129 open flame ignition standard. While most states do not require that institutional and commercial mattresses pass this standard, mattresses that pass the TB 129 standard are available to consumers nation-wide. Such mattresses would be special order items from retail, available to the consumer within one week of purchase (most often in one to two days). However, mattresses passing the TB 129 standard are more expensive than most residential mattresses that don't pass the standard, presenting a disincentive for consumer orders. Also, retailers are not likely to promote such sales actively, choosing to avoid the topic of perceived safety issues and the desire to move existing stock rather than special order items.

# Tab D

# SLEEP PRODUCTS SAFETY COUNCIL

## Hang tag for Mattresses

The manufacturer of this mattress certifies it is made in compliance with the U.S. Federal Mattress Flammability Standard, which requires that all mattresses resist ignition by smoldering cigarettes. Conformance with the Federal Standard ensures the reduction of this hazard, but not necessarily its elimination.

Fires can occur if the mattress, foundation or bedding comes into contact with an open flame, such as a match, lighter or candle. When ignited, some mattress filling materials can burn rapidly and emit hazardous gases.

El fabricante de este colchón certifica que está hecho bajo las Normas Federales Norteamericanas de Flamabilidad de Colchones (U.S. Federal Mattress Flammability Standard), los cuales requieren que todos los colchones sean resistentes a incendiarse por cigarrillos encendidos. El cumplimiento con los Estándares Federales asegura la reducción del riesgo a incendiarse, pero no lo elimina.

Los incendios pueden ocurrir si el colchón, la base/somier, o las sábanas llegan a tener contacto directo con una llama, tal como un fósforo, un encendedor o una vela. Al incendiarse, algunos materiales el colchón pueden quemarse rápidamente y emitir gases tóxicos.

These safety messages from the SPSC are sponsored by/  
Estos mensajes de seguridad de SPSC están avalados por:

American Academy of Pediatrics  
National Association of State Fire Marshals  
U.S. Consumer Product Safety Commission  
U.S. Fire Administration

The SPSC is a non-profit organization (supported in part by the manufacturer of this mattress) devoted to creating safer and healthier sleep environments.

SPSC es una organización sin fines de lucro (patrocinada por el fabricante de este colchón) dedicada a crear ambientes sanos y seguros para dormir.

**TO PROTECT YOUR HOME AND FAMILY**



**PROTEJA A SU HOGAR Y SU FAMILIA**

### To Protect Your Family From Fire...

- Keep matches and lighters in a secured drawer or cabinet, out of reach of children.
- Check under beds and in closets for burnt matches, evidence your child may be playing with fire.
- Keep lit candles away from bedding, curtains, sleepwear and anything else that can ignite easily.
- Don't smoke in bed.
- Keep bedding, clothes, curtains and other flammable items at least 3 feet away from portable heaters.
- Do not store old mattresses in the home or garage; they are a fire hazard.

- Make sure everyone in your family knows at least two escape routes from their bedrooms, and practice these often.

- Install and maintain at least one working smoke alarm on each level of your home, preferably in the hall outside each bedroom.
- Teach children to "stop, drop and roll" if their clothing catches fire.

### To Help Your Children Sleep Safe...

- Remove and discard plastic wrapping; a child can become entangled and suffocate.
- Use only tight-fitting sheets.

- Never allow a child under 6 years on an upper bunk.
- Position your infant on his or her back during sleep, as recommended by the American Academy of Pediatrics.
- Place infants in cribs meeting current safety standards; use a mattress that fits tightly.
- Never leave an infant on an adult-size mattress; infants can suffocate if trapped between the mattress and the wall, bed frame, footboard or headboard.
- Never sleep in the same bed as an infant; infants can suffocate if an adult rolls over on them.

**WARNING: Children playing with matches, lighters and candles is a leading cause of home fires.**

### Para proteger a su familia de los incendios...

- Mantenga los fósforos y encendedores fuera del alcance de los niños y en un lugar con seguro, tal como una gaveta o gavinete.
- Busque debajo de las camas y en los armarios (closets) fósforos quemados, lo cuales son evidencia de que sus hijos han estado jugando con fuego.
- Mantenga las velas encendidas lejos de la cama, cortinas, ropa de dormir (pajamas) y cualquier otra cosa que pueda encenderse con facilidad.
- No fume en la cama.
- Mantenga las sábanas, ropas, cortinas, y otros objetos inflamables por lo menos a 3 pies (1 metro) de distancia de calentadores portátiles.

- No guarde colchones viejos en la casa o en el garage; éstos presentan un riesgo de incendio.
- Asegúrese de que cada persona en la familia conozca por lo menos dos rutas de escape desde sus dormitorios y póngalas en práctica con frecuencia.
- Instale y mantenga funcionando por lo menos una alarma de humo en cada nivel de su casa y en los pasillos fuera de los dormitorios.
- Enseñe a sus niños a "detenerse, tirarse al suelo y echarse a rodar" si su ropa se incendia.

### Para ayudar a que sus hijos duerman seguros...

- Quite y bote la cubierta plástica del colchón; el niño puede enredarse en el plástico y asfixiarse.
- Use solamente sábanas muy ajustadas.

- Nunca permita niños menores de seis (6) años en una cama de dos niveles (camarote).
- Coloque a su bebé de espaldas mientras duerma, según lo recomienda la Academia Americana de Pediatría (American Academy of Pediatrics).
- Coloque a su bebé en cunas que cumplan con las normas de seguridad vigentes; use un colchón que quepa apretado en la cuna.
- Nunca deje a un bebé en un colchón diseñado para adultos; el bebé puede asfixiarse si quedar atrapado entre el colchón y la pared, el marco de la cama, o los espaldares de la cama.
- Nunca duerma en la misma cama con un bebé; un adulto, al darse vuelta encima, puede sofocar al bebé.

**ADVERTENCIA: La causa principal de incendios en el hogar es debido a niños que juegan con fósforos, encendedores y velas.**

# SLEEP PRODUCTS SAFETY COUNCIL

## Permanent Safety Label for Mattresses

SPSC Permanent Safety Label

### To Protect Your Home and Family

Important safety messages from the Sleep Products Safety Council.

### Proteja a su Hogar y su Familia de los Incendios.

Mensajes de seguridad importantes del Consejo de Seguridad de Productos para Dormir ("Sleep Products Safety Council") (SPSC).

#### To Protect Your Family From Fire...

- Keep matches and lighters in a secured drawer or cabinet, out of reach of children.
- Check under beds and in closets for burnt matches, evidence your child may be playing with fire.
- Keep lit candles away from bedding, curtains, sleepwear and anything else that can ignite easily.
- Don't smoke in bed.
- Keep bedding, clothes, curtains and other flammable items at least 3 feet away from portable heaters.
- Do not store old mattresses in the home or garage; they are a fire hazard.
- Make sure everyone in your family knows at least two escape routes from their bedrooms, and practice these often.
- Install and maintain at least one working smoke alarm on each level of your home, preferably in the hall outside each bedroom.
- Teach children to "stop, drop and roll" if their clothing catches fire.

#### To Help Your Children Sleep Safe....

- Remove and discard plastic wrapping; a child can become entangled and suffocate.
- Never allow a child under 6 years on an upper bunk.
- Position your infant on his or her back during sleep, as recommended by the American Academy of Pediatrics.
- Never leave an infant on an adult-size mattress; infants can suffocate if trapped between the mattress and the wall, bed frame, footboard or headboard.
- Never sleep in the same bed as an infant; they can suffocate if wedged between your body and the mattress.
- Place infants in cribs meeting current safety standards; use a mattress that fits tightly.

**WARNING:**  
Children playing with matches,  
lighters and candles is a leading  
cause of home fires.

The manufacturer of this mattress certifies it is made in compliance with the U.S. Federal Mattress Flammability Standard, which requires that all mattresses resist ignition by smoldering cigarettes. Conformance with the Federal Standard ensures the reduction of this hazard, but not necessarily its elimination.

Fires can occur if the mattress, foundation or bedding comes into contact with an open flame, such as a match, lighter or candle. When ignited, some mattress filling materials can burn rapidly and emit hazardous gases.

The SPSC is a non-profit organization (supported in part by the manufacturer of this mattress) devoted to creating safer and healthier sleep environments.

SPSC es una organización sin fines de lucro (patrocinada por el fabricante de este colchón) dedicada a crear ambientes sanos y seguros para dormir.

#### Para proteger a su familia de los Incendios...

- Mantenga los fósforos y encendedores fuera del alcance de los niños y en un lugar con seguro, tal como una gaveta o gavinete.
- Busque debajo de las camas y en los armarios (closets) fósforos quemados, lo cuales son evidencia de que sus hijos han estado jugando con fuego.
- Mantenga las velas encendidas lejos de la cama, cortinas, ropa de dormir (pajamas) y cualquier otra cosa que pueda encenderse con facilidad.
- No fume en la cama
- Mantenga las sábanas, ropas, cortinas, y otros objetos inflamables por lo menos a 3 pies (1 metro) de distancia de calentadores portátiles.
- No guarde colchones viejos en la casa o en el garage: éstos presentan un riesgo de incendio.
- Asegúrese de que cada persona en la familia conozca por lo menos dos rutas de escape desde sus dormitorios y póngalas en práctica con frecuencia.
- Instale y mantenga funcionando por lo menos una alarma de humo en cada nivel de su casa y en los pasillos fuera de los dormitorios.
- Enseñe a sus niños a "detenerse, tirarse al suelo y echarse a rodar" si su ropa se incendia.

#### Para ayudar a que sus hijos duerman seguros...

- Quitar y botar la cubierta plástica del colchón; el niño puede enredarse en el plástico y asfixiarse.
- Nunca permita niños menores de seis (6) años en una cama de dos niveles (camarote).
- Coloque a su bebé de espaldas mientras duerma, según lo recomienda la Academia Americana de Pediatría (American Academy of Pediatrics).
- Nunca deje a un bebé en un colchón diseñado para adultos; el bebé puede asfixiarse si quedar atrapado entre el colchón y la pared, el marco de la cama, o los espaldares de la cama.
- Nunca duerma en la misma cama con el bebé; los bebés pueden asfixiarse si quedan atrapados entre su cuerpo y el colchón.
- Coloque a su bebé en cunas que cumplan con las normas de seguridad vigentes; use un colchón que quepa apretado en la cuna.

**ADVERTENCIA:**  
La causa principal de incendios en el  
hogar es debido a niños que juegan con  
fósforos, encendedores y velas.

El fabricante de este colchón certifica que está hecho bajo las Normas Federales Norteamericanas de Flamabilidad de Colchones (U.S. Federal Mattress Flammability Standard), los cuales requieren que todos los colchones sean resistentes a incendiarse por cigarrillos encendidos. El cumplimiento con los Estándares Federales asegura la reducción del riesgo a incendiarse, pero no lo elimina.

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U.S. Consumer Product Safety Commission • U.S. Fire Administration

# SPSC

*Sleep Products  
Safety Council*

June 23, 2000

Honorable Ann Brown, Chairman  
U.S. Consumer Product Safety Commission  
4330 East West Highway  
Bethesda, MD 20814-4408

Dear Chairman Brown:

The Sleep Products Safety Council ("SPSC") wishes to express its support for the Consumer Product Safety Commission's plan to issue an advance notice of proposed rulemaking for the purpose of deciding whether to modify the Commission's existing mattress flammability standard, codified at 16 C.F.R. Part 1632, with the aim of further reducing the incidence of mattress fires.

As you are aware, SPSC was established in 1986 as a non-profit organization to disseminate consumer safety information, support research, and promote public educational and other activities aimed at reducing hazards associated with sleep products. SPSC is affiliated with the International Sleep Products Association, an industry trade association established in 1915 to represent the interests of mattress manufacturers and their suppliers in the United States, Canada, and abroad.

The mattress industry takes seriously its responsibility to provide consumers with a product that is safe, comfortable, and affordable. In the early 1970s, the industry worked closely with federal safety regulators in developing the existing federal cigarette-ignition mattress flammability standard, which became effective in 1973. Subsequently, SPSC has funded and closely cooperated with the National Association of State Fire Marshals ("NASFM") in developing critical research to assist in understanding home mattress fires and their causes. We are also engaged in a variety of public education activities, including product safety labeling and collaborative campaigns with organizations such as the U.S. Fire Administration to educate consumers on residential fire prevention.

In 1997, the industry resolved to explore the possibility of revising the existing federal flammability standard to improve mattress resistance to open-flame ignition. As it did 30 years ago when the industry assisted the federal government in establishing the current mattress standard, the industry continues to believe that a sound understanding of the problem, the performance objectives to be achieved, and the technical means for meeting those objectives will be critical in developing a new standard. This effort requires a thorough evaluation of the fire characteristics of the typical residential bedding scenario -- including the mattress and foundation, sheets, blankets, mattress pads, pillows, comforters, and other items that can have a significant impact on the size and intensity of a mattress fire.

more



As a first step in this process, SPSC began work with the National Institute of Standards & Technology ("NIST") in 1998 to conduct precedent-setting scientific research on these subjects. The first phase of this research has just been concluded. It focused on the fire behavior of mattresses when used with typical bedroom accessories (i.e., sheets, blankets, mattress pads, pillows, etc.) and the development of testing equipment that will consistently simulate the type of fire that those accessories create on a mattress. I am pleased to enclose a copy of NIST's report of this initial research dated June 2000. The data generated by this study will provide a solid basis for further analysis in determining the most effective approach for addressing the open-flame problem in a manner that is both relevant to real-life residential scenarios and feasible from an economic and technical perspective.

Now that this initial work is completed, we are working with NIST to carry out additional scientific research that will be needed in the standards-setting process. The next phase of study includes the extent to which mattress size (for example, twin, double, queen, king) affects the size and intensity of a bedroom fire, the types of fire-related hazards that will be addressed at different levels of fire reduction, and the feasibility of a mattress manufacturer using a small-scale mattress to test compliance with a new cigarette/open-flame standard.

The SPSC believes that the institution of a proposed rulemaking proceeding by the Commission is appropriate at this juncture to analyze the open-flame ignition problem. Scientific knowledge and technology have advanced significantly since the early 1970's when the present mattress flammability standard was issued. Although we believe that further important research on this problem along the lines described above must be carried out before the existing standard can be modified to address open-flame ignitions, we also believe that industry and government are now much better equipped to examine the complexities of this subject.

Furthermore, NIST's scientific research is at a sufficiently advanced stage that the Commission's input from a consumer safety and scientific perspective will be very helpful in carrying out the next phase of research. In addition, we are aware that the Flammable Fabrics Act imposes substantial procedural and public comment responsibilities on the Commission when it undertakes to promulgate a flammability standard. We believe that it is appropriate to set this administrative machinery in motion now so that these proceedings can occur in tandem with the scientific research that remains to be done.

Accordingly, we support the Commission's publication of an advance notice of proposed rulemaking at this time to analyze the feasibility of establishing a new mattress flammability standard that would address the issue of residential mattress resistance to both cigarette and open-flame ignitions. On behalf of the industry, we look forward to working further with the Commission in carrying out this important task. As we were 30 years ago, the industry remains committed to improving the performance of its products and to cooperating with the Commission in developing an appropriate approach that will provide consumer choice and value while enhancing consumer safety, and be workable for the industry.

Sincerely,



Patricia A. Martin  
Executive Director

Enclosure

cc: Ronald Medford, Office of Hazard Identification & Reduction, CPSC  
Margaret Neily, Directorate of Engineering Sciences, CPSC

# Tab E



U.S. CONSUMER PRODUCT SAFETY COMMISSION  
WASHINGTON, D.C. 20207

April 25, 2001

TO: Margaret Neily, Project Manager  
Directorate for Engineering Sciences

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

FROM: Allyson Tenney, M.S., Textile Technologist *ATW*  
Directorate for Engineering Sciences

SUBJECT: Review of Existing Open-flame Mattress Flammability Standards

### Introduction

Mattress and bedding fires pose a unique and complex fire hazard. The complexity of the hazard is evident in that a typical bed consists of several components. A typical bed is composed of a mattress and foundation used with a collection of bedclothes that may include a mattress pad, sheets, pillows, blankets, quilts and comforters. In most cases, the various products come from several manufacturers and are used together to form a bed ensemble. Since a single manufacturer is not responsible for all of the bed components, one manufacturer is not responsible for the potential fire hazard of the complete bed.

The bedclothes are particularly unique in that they are a potential secondary source of ignition to the mattress. If they are the first items to ignite in an incident, the bedclothes magnify the ignition source seen by the mattress. While in some incidents the mattress is reported as the first item to ignite, in many more cases, the bedclothes are reported as the first item ignited. According to a CPSC investigation of 431 mattress and bedding fires since 1994, a mattress was found to be the first item ignited in 92 cases, 33% of the cases investigated in which the item first ignited was specified. The bedding was found to be the first item ignited in 146 of the cases, 52% of the cases investigated (Hiser, 2000). The other known ignition sources were electric blankets and foundations. In addition, tests of the individual bed components do not reveal the likely fire performance of the complete bed.

Several existing standards address small-open flame mattress ignition. Most are voluntary and have been developed by standards developing organizations, state governments and other national governments. A small number have been adopted as mandatory regulations in several local jurisdictions, individual states and countries. This memo is a review of presently recognized standards and test procedures that address mattress ignition by small open-flame with potential relevance to reducing this hazard scenario.

## **United States Standards**

### State of California

#### TB 129

Several test methods were developed by the State of California, Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation. One test method is Technical Bulletin 129 (TB 129), *Flammability Test Procedures for Mattresses for use in Public Buildings*. TB 129 was developed in 1992 to address hazards associated with ignition of mattresses in public institutions including prisons, dormitories, health care facilities, hotels and other public occupancies. It is intended for contract applications. TB 129 is a voluntary standard and not used for regulatory purposes.

TB 129 is a full-scale fire test which measures resistance of a finished mattress to open flame sources which might be encountered in an accidental or arson-caused fire in a public occupancy. The mattress can be tested either with or without bedding but generally the test is conducted on a bare mattress with no foundation or bed clothing (TB129: 2000). The test is conducted using one of three available options. The first two options specify using a test room of two specified sizes with a hood outside of the doorway with the mattress placed in the corner of the test room. The third option uses a furniture calorimeter with the mattress placed directly underneath the hood. During the test, the mattress is placed on a weighing platform and the side of the mattress is exposed to a propane gas T-burner tube (heat input 17.8 kW) for 180 seconds/3 minutes. The heat source is intended to simulate a wastebasket filled with burning newspaper. Heat release (measured by an oxygen consumption technique), mass loss and smoke production are measured during the test. To comply with TB 129, the peak heat release rate should not exceed 100 kW and mass loss can not exceed 3 pounds in the first 10 minutes of the test.

Concerns regarding the effectiveness of the standard include the degree to which TB 129 resembles a real residential mattress fire scenario since it was developed for mattresses used in non-residential scenarios. The test does not require testing with clothing or a foundation, while most real life residential fire scenarios involve both bed clothing and foundation. If bed clothing is used during the test, the choice of bedding items can affect the test results and the results may be inconclusive. The ignition source of the burner has a considerably lower heat release rate than that of typical burning bed clothing, a common ignition source of residential mattress fires. There is also concern regarding the point of ignition since the test is conducted only on the side of the mattress while many residential fires also involve the top of the mattress. In addition, the full-scale tests such as TB 129 are expensive and can not be conducted by a majority of testing laboratories.

Although TB 129 is not an enforceable standard in California, it has been adopted as a voluntary consensus standard by ASTM (formally the American Society of Testing and Materials) as E-1590 and by the National Fire Protection Association (NFPA) as NFPA 267 as

referenced in Life Safety Code, NFPA 101. Both standards will be discussed in further detail in a separate section.

### TB 121

The predecessor of TB 129 was Technical Bulletin 121 (TB 121) *Flammability Test Procedures for Mattresses for use in High-risk Occupancies*. TB 121 was developed in 1980 as a procedure for evaluating jail pad type products used in jails, prisons and penal institutions. It is a mandatory prison standard enforced by the California Bureau of Corrections. TB 121 is a full-scale fire test intended to represent a deliberate ignition of an institutional mattress or jail pad.

The test is conducted by placing a weighed mattress on a spring support in the corner of a test room. The mattress is ignited by a galvanized steel container containing ten double sheets of newsprint which have been lit by a single match. The container is placed underneath the mattress, one inch from the underside, in the geometric center of the mattress. Measurements of weight loss, room temperature (measured by a thermocouple above the mattress), carbon monoxide concentration, and smoke production are recorded. The mattress fails if the weight loss amount is greater than 10% during the first 10 minutes of the test, the temperature above the mattress exceeds 500 F at any time during the test, or the carbon monoxide concentration exceeds 1,000 ppm.

According to the scope of TB 121, the test procedure is not intended for the evaluation of residential mattresses. Bed clothing and mattress foundations, both typical of residential fire scenarios, are not incorporated in the standard. The ignition source, which represents a trash can fire, is not clearly defined by a specified heat release rate. Trash can fires are not typical ignition sources of mattresses in residential fire scenarios making the specified ignition source not comparable to an ignition source of burning bedding. The position of the ignition on the underside of the mattress is not typical of those found in residential incidents.

### TB 117

A component test developed by the State of California is Technical Bulletin 117 (TB 117) *Requirements, Test Procedure and Apparatus for Testing the Flame Retardance of Resilient Filling Materials used in Upholstered Furniture*. TB 117 is a mandatory standard developed in 1980, requiring all filling and stuffing materials used in upholstered furniture to be flame retardant and smolder resistant. The standard is applicable for mattresses if the mattress contains flexible polyurethane foam. However, in the case of mattresses, the mattress can either contain flame resistant (FR) polyurethane foam, which complies with TB 117, or it can have a permanent label stating that the mattress contains non-FR foam.

TB 117 is a component test that only evaluates foam filling materials. It does not apply to finished products. To conduct the test, specimens are placed in a holder and put into a chamber at a 45 degree angle. The near lower edge of the specimen is exposed to a 5/8 inch burner flame for 5 seconds. The time required for the flame to proceed up the specimen a distance of 5 inches is recorded. A specimen meets TB 117 if the average flame spread of all specimens is not less than 10 seconds and any one specimen is not less than 7 seconds.

There are several component tests for foam. However, there is no assurance that tests on individual components have any relation to the likely fire performance of a completed product. Damant and Nurbakhsh explain that for complex structures such as mattresses, full-scale fire testing repeatedly shows fire performance that often bears little relationship to the fire properties of the components used to make the product (1991). The ignition source is not adequate for

residential scenarios and the flame spread rate criteria do not prevent ignition or limit fire growth.

### State of Michigan

#### The Michigan Roll-up Test

The *Michigan Roll-up Test* is a test procedure developed by the staff of a state prison in Jackson, Michigan. The test involves rolling a mattress until the internal diameter is nine inches and tied at three points with wire. Eight double sheets of newsprint are stuffed into the interior of the mattress. The mattress is placed at a 75 degree angle against a prison bed frame and the newsprint is ignited by a single match at the bottom of the mattress.

The test reflected actual inmate attempts to burn mattresses and does not reflect a typical residential fire scenario. The test does not specify any criteria for evaluation nor does it include bed clothing and foundations in the methodology. The standard's effectiveness is in question since it involves rolling the mattress, a procedure not possible for most typical residential mattress constructions, the ignition source and point of ignition are inconsistent and inadequately represent a typical residential mattress fire ignition source. The test appears to be obsolete and is not being used by any known organizations for testing mattresses.

### Boston, Massachusetts

#### BFD IX-11

Test method BFD IX-11 was developed by the Boston Fire Department's Fire Prevention Unit in 1993. The current test method is a variation of California's TB 129; however, there is a provision that allows the use of Underwriters Laboratories Standard UL 2060. The test is used for contract applications and is mandated for public occupancies (i.e. hotels, health care facilities and dormitories) in the City of Boston and by the State of Massachusetts Corrections Department. It is also referenced in other states including the New York State's Department of Corrections.

The test is a full-scale test and uses bedclothes as the primary fuel source for the fire in an attempt to create a scenario as close to real-life as possible. A mattress is tested with a flat sheet, fitted sheet, a blanket, and pillow and pillowcase. The bedding is partially folded back and allowed to hang down the side of the mattress. The bottom side edge of the bedding is ignited with a two to four inch flame. Mass loss and peak heat release are measured. To meet the standard, the peak heat release of the mattress and bedding can not exceed 150 kW (less severe than TB 129), the mass loss can not exceed the mass of the bedding used during the test, and the maximum concentration of carbon monoxide can not exceed 1,000 ppm for more than 5 minutes.

BFD IX-11 uses bedding as the primary source of ignition to reflect a real-life scenario. However, extensive variability exists with the selection of bedclothes and the respective heat release rates of the various bed clothing. The inconsistency of the heat release rate of the ignition source subjected to the mattress causes inconsistent test results making the pass/fail criteria inconclusive and insufficient for a regulation. In addition, the point of ignition is also not suitable. An appropriate standard needs to be repeatable and representative of the real life hazard, neither of which are met by the test method set forth in BFD IX-11.

## American Society of Testing & Materials

### ASTM E-1590 & ASTM E-1474

ASTM (formally the American Society of Testing & Materials), a voluntary standards developing organization, adopted California's TB 129 as ASTM E-1590—*Standard Test Method for Fire Testing Mattresses*. The test method is the same as TB 129 except there are no specified pass/fail criteria.

ASTM also has a component test relevant to mattress fires, ASTM E-1474—*Standard Test Method for Determining the Heat Release Rate of Upholstered Furniture and Mattress Components or Composites Using a Bench Scale Oxygen Consumption Calorimeter*. ASTM E-1474 measures ignitability and heat release rates of mattress components after radiant thermal exposure. The specimens are horizontally oriented and spark ignited. There are no specified pass/fail criteria. Similar to the problem with other component tests, there is no assurance that a fully completed mattress will exhibit the same fire performance of the components. The National Fire Protection Association (NFPA) references both ASTM standards in NFPA 267 and 272, respectively.

## National Fire Protection Association

### NFPA 267 & NFPA 272

The National Fire Protection Association has adopted a version of California's TB 129, known as NFPA 267—*Standard Method of Test for Fire Characteristics of Mattresses and Bedding Assemblies Exposed to Flaming Ignition Source*. NFPA 267 is required under NFPA 101, Life Safety Code for Interior Finish, Contents and Furnishings. Unlike ASTM E-1590, NFPA 267 has specified pass/fail criteria when used in conjunction with NFPA 101. To comply with the Life Safety Code, the peak heat release of a mattress fire can not exceed 250 kW under test method ASTM E-1590 (based on TB 129) and the total energy release can not exceed 40 MJ during the first 5 minutes of the test.

The NFPA also has a component standard for mattress foam, NFPA 272, which is the same as ASTM E-1474, a test method used for mattress components. There are no specified pass/fail criteria.

## Underwriters Laboratories

### UL 1895 & UL 2060

Underwriters Laboratories (UL) has two current test methods relevant to mattresses. One test is UL 1895-*Fire Tests of Mattresses*, a full-scale fire test. The test is conducted using a collection hood and exhaust duct or furniture calorimeter. The mattress, without a foundation, is centered under the hood on a metal bed frame and ignited with a T-shaped gas burner, similar to the burner used in TB 129. The side of the mattress is exposed to the burner for 180 seconds. The test mattress passes the test if the total heat release rate does not exceed 25 MJ during the first five minutes of the test and if the maximum heat release rate does not exceed 100 kW at any time during the test. The test does not measure the density of the smoke produced or the toxicity

of the combustible products but it does offer an optional procedure for weight loss measurements.

The second test is UL 2060-*Fire Tests of Mattresses with Bedclothes using a Furniture Calorimeter*. UL 2060 is the same test as specified in UL 1895 except bed clothing is added to the mattress. The added bed clothing is specified as two sheets and a pillow with a pillowcase. The performance criteria are the same for those specified in UL 1895, except the peak heat release rate of the mattress and the bedclothes together can not exceed 150 kW and the total heat release of the mattress and bedclothes can not exceed 25 MJ during the first 10 minutes of the test.

Both UL tests require expensive laboratory facilities since they are full-scale fire tests using furniture calorimeters. The necessary equipment needed to conduct the tests makes it a test that can only be conducted by a selective number of laboratories, making it a test that is not viable for a majority of mattress manufacturers. The test does not account for mattress foundations, raising a question as to how closely the test relates with real life conditions since a foundation is typically used in residential settings. The ignition source and point of ignition inadequately represent typical residential mattress fire scenarios.

## **International Standards**

### United Kingdom

#### BS 6807

The United Kingdom Department of Trade and Industry has developed several test methods that are relevant to small open-flame mattress fires. One test method is British Standard 6807 (BS 6807)—*Methods of Test for Assessment of the Ignitability of Mattresses, Divans and Bed Bases with Primary and Secondary Sources of Ignition*. BS 6807 is a series of test methods for both full-size and smaller scale mattresses and foundations using primary and secondary ignition sources of differing severity. The test method describes two testing options, one option for bare mattresses and foundations using primary ignition sources and the other for testing with known bedclothes which are used as a secondary ignition source to which the primary ignition sources are applied. In both options, the ignition source can be placed either on top of or below the test specimen. The ignition sources range in severity from two different butane flames to four different wood cribs.

The testing is conducted in a test room with the specimen placed on a flat test rig of either expanded steel or open mesh or a finished mattress foundation. The specimen is exposed to the pre-determined ignition source and observed for smoldering or flaming. Ignition propensity is determined by observing any progressive smoldering or flaming ignition of the specimens as set forth in the standard.

#### BS 5852

BS 5852 is a two-part fire test method for furniture. Part 2, *Methods of Test for the Ignitability of Upholstered Composites for Seating by Smouldering and Flaming Ignition Sources*, is a mandatory standard for upholstered furniture. Under British regulations, only mattresses made with a single filling are subject to the test. The test is conducted by placing the mattress foam on an L-shaped rig and covered with a woven test fabric composed of 100% FR

polyester. The L-shaped junction is exposed to the appropriate ignition source, ranging in severity from a cigarette, three different butane flames, and four different wood cribs. The specimen passes the test if progressive smoldering or flaming is not observed after 10 minutes and if smoldering does not continue for more than a total of 60 minutes or if the total mass loss does not exceed 60g. Similar to the problem with other component tests, there is no assurance that a fully completed mattress will exhibit the same fire performance as the components.

### BS 7177

BS 7177—*Specification for Resistance to Ignition of Mattresses, Divans and Bed Bases*, sets forth the performance requirements of mattresses depending on the end-use application (residential use-low risk to prison use-very high risk) when tested in accordance with BS 6807, BS 5852 and EN 597.

### European Committee for Standardization

### EN 597

The European Committee for Standardization (CEN) has adopted EN 597, a two-part standard used to assess the ignitability of mattresses and foundations from cigarette smoldering and match flame equivalents. EN 597, Part 2—*Assessment of the Ignitability of Mattresses and Upholstered Bed Bases using a Match Flame Equivalent Ignition Source*, specifies a test method for assessing mattresses, foundations or mattress pads when subjected to a match flame equivalent gas flame ignition source. The test can be conducted using either full-scale mattresses or representative small-scale specimens. The specimens are placed on a test rig, similar to the one specified in the British standards, or on a mattress foundation, if applicable. The gas flame ignition source is placed horizontally on the upper surface of the mattress for 15 seconds. The specimen is assessed for any evidence of progressive smoldering ignition and flaming ignition as specified in the standard.

### **Discussion**

This memo is a review of currently existing standards that address mattress ignition by small-open flame. Particular attention was paid to standards that have the potential to reduce the serious and complex hazard of mattress and bedding fires. The staff is not convinced that any of the existing standards have the potential to adequately reduce the hazard of residential mattress fires caused by small open flame ignition.

Many of the tests were developed to address mattress fires in high-risk occupancies such as prisons or for contract applications such as dormitories and health care facilities. There are significant differences between mattresses used in institutions compared to mattresses typically used in residential settings. One difference is the mattress construction. The typical construction of a residential mattress involves an innerspring of coiled steel springs sandwiched between foam, batting and padding which is covered with quilted ticking and edge tape. Ninety percent of residential mattresses sold in the United States have innerspring cores (ISPA, 2000). A standard residential mattress has a thickness of about 9 or 10 inches. Pillow top and ultra cushion top mattresses, mattresses having an extra cushion on both sides, can be as much as 18 inches thick. In comparison, institutional mattresses are made from slab foam, having no

innerspring core, and have a thickness range of 3 inches for penal institution mattresses to about 6 or 8 inches for mattresses used in hospitals and similar applications. They are usually covered with vinyl ticking.

In addition to the differences in mattress construction, another difference is the manner in which the mattresses are typically used. Most of the existing standards call for testing on bare mattresses and do not include the use of a mattress foundation. Residential mattresses are designed to work with a corresponding foundation, usually with a standard thickness of 9-10 inches, and a mattress frame. A collection of bed clothing, which may include a mattress pad, sheets, pillows, blankets, quilts, or comforters in varying quantities, typically completes the bed ensemble. In comparison, slab foam mattresses used in high risk and institutional settings, are not commonly used with comparable foundations but instead use an open spring metal frame. The bedding is most often limited in quantity and is consistent within the particular institution.

The bedding often plays a significant role in residential mattress fires as it is a potential secondary source of ignition to the mattress. The bed clothes magnify the source of ignition if they are the first item to ignite, which is the case in a majority of the reported incidents (Hiser, 2000). If the bedding is the first item to ignite, the mattress is essentially exposed to burning bedding which may have a heat release rate of approximately 200 kW, a much larger ignition source than any of the ignition sources represented in the existing standards.

The point of ignition set forth in most of the existing standards is on the side of the mattress, representing a possible institutional mattress fire scenario. According to CPSC data, residential mattress fires due to open flame ignition sources occurred in a variety of locations on the mattress (Hiser, 2000). The applicability of test methods having a side point of ignition is unclear since it is not a true and direct measure of the danger posed in a typical mattress fire scenario.

## **Conclusion**

A reasonable standard needs to effectively address the hazard under conditions that closely resemble real-life fire scenarios. Although several of the existing standards may offer useful methodologies, it appears that none of them are applicable for addressing the specific hazard of open flame residential mattress fires. Many of the tests are one step away from the real fire scenario, many have an inferior heat source or point of ignition and most do not adequately address bedding and foundations, making it unclear as to the level of product performance assessed by the specified methodology. The staff is not convinced that any of the existing standards as currently written are appropriate for addressing the hazard as required by the Flammable Fabrics Act (FFA) Section 4.

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## FULL SCALE MATTRESS TESTS

Title	Specimens *L1			Ignition source & location, real life hazard	KW/time of exposure	Criteria**	Use of Standard	Comments
	M	F	B					
TB 129	x	L2	L3	Gas burner on side of mattress, simulating newspaper fire in waste basket	17.8 kW/3 min.	Max. prhr 100 kW, max. 3 lbs mass loss in 10 min.	Contract requirements, commercial occupancies	
ASTM E-1590	x	L2	L4	Gas burner on side of mattress, simulating newspaper fire in waste basket	17.8 kW/3 min.	None specified	Voluntary Standard	Similar to TB 129
NFPA 267	x	L2	No	Gas burner on side of mattress, simulating newspaper fire in waste basket	17.8 kW/3 min.	Max. prhr 250 kW, max total energy release 40 MJ during first 5 min.	Required under NFPA 101, the Life Safety Code for interior contents & furnishings (Chap 10) as adopted by local jurisdictions.	Similar to TB 129 & ASTM 1590
TB 121	x			10 sheets newsprint in steel container under mattress, simulating deliberate ignition by inmate		Max. 500 degrees F in room, 1,000 ppm CO, or mass loss > 10% in 10 min.	Mandatory prison standard, California Bureau of Corrections	Predecessor of TB 129
BFD 1X-11	x	L2	X L5	Bedding—sheets, blanket, pillow, and pillowcase, bottom edge of folded back bedclothes	Dictated by bedding items used 2-4 in. flame	Max. prhr 150 kW, mass loss no greater than bedding mass, max. 1,000 ppm CO	Contract requirements, mandatory for City of Boston public occupancies, State of Mass. Corrections Dept., NY State Dept. of Corrections	Similar to TB 129 and UL 2060

Title	Specimens			Ignition source & location, real life hazard	KW/time of exposure	Criteria	Use of Standard	Comments
	M	F	B					
UL 1895	x	No		Gas burner on side of mattress, similar to TB 129 simulation of newspaper fire in wastebasket	17.8 kW for 3 min	Max. prhr 100 kW, max total heat release 25 MJ in first 5 min (wt. loss meas. optional)	Voluntary standard for UL-listed mattresses.	Similar to TB 129
UL 2060	x	No	x	Gas burner from UL 1895, two sheets, pillow and pillowcase	17.8 kW for 3 min	Max. prhr 150 kW, max total heat release 25 MJ in first 10 min	Voluntary standard	Similar to TB 129 and UL1895
BS 6807	x	L2	x, part 3 only	Multiple options— 2 butane flames, 4 wood cribs of varying sizes, bedclothes	varying	Ignition/non ignition determination	Voluntary standard	
Michigan Roll Up Test	x			8 sheets newsprint stuffed in rolled and tied mattress, 75 degree angle simulating deliberate ignition.		None specified	Obsolete test method	

\*Key

L1 M=Mattresses  
F=Foundation  
B=Bedclothing

L2 Optional  
L3 Optional, Unspecified  
L4 Optional, in appendix  
L5 Materials are specified

\*\* prhr=peak rate of heat release

## SMALL SCALE TESTS

Title	Specimens	Ignition Source, location, real life hazard	KW/time of exposure	Criteria	Use of Standard	Comments
TB 117	Polyurethane foam	5/8 in flame, near bottom edge of 5 in specimen	5 sec at 45 degree angle	Average flame spread no greater than 10 sec	Mandatory standard in California for mattresses containing polyurethane foam	
ASTM E-1474	Mattress components	Cone Calorimeter test, top surface exposure, spark	35 kW/m <sup>2</sup>	Time to flaming ignition, heat release rate	Voluntary standard	Bench scale oxygen consumption
NFPA 272	Mattress components	Cone Calorimeter test, top surface exposure	35 kW/m <sup>2</sup>	Ignitability, time to flaming, heat release rate @ 180s	Voluntary standard	Similar to ASTM E-1474 Prev. NFPA 264A Radiant exposure
BS 5852	Foam of single-filling mattresses	Multiple options -- cigarette, 3 butane flames, 4 wood cribs of varying sizes	Exposed at horizontal/vertical crevice of filling covered w/ FR polyester fabric.	No progressive smoldering or flaming after 10 min OR max smoldering time 60 min or max mass loss 60 g.	Mandatory for mattress filling materials in single-filling mattresses	

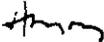
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U.S. CONSUMER PRODUCT SAFETY COMMISSION  
WASHINGTON, D.C. 20207

April 25, 2001

TO: Margaret Neily, Project Manager  
Directorate for Engineering Sciences

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

FROM: Allyson Tenney, M.S., Textile Technologist   
Directorate for Engineering Sciences

SUBJECT: Current Research Program to Evaluate Open-flame Mattress Flammability

### Introduction

Mattress fires became a concern in the early 1970's. Early data obtained from the United States Fire Administration (USFA) and the National Fire Protection Association (NFPA) showed that about 60-70 percent of mattress fires were caused by cigarettes or smoking materials that were either carelessly discarded or had accidentally come in contact with the bedding. To address the problem, the Secretary of Commerce promulgated the Federal Mattress Flammability Standard in 1972 (DOC FF 4-72) mandating that every mattress offered for sale in the United States be cigarette resistant. The standard was transferred to the Consumer Product Safety Commission (CPSC) shortly thereafter and codified with its current designation as 16 CFR 1632—Standard for the Flammability of Mattresses and Mattress Pads.

CPSC studies documented the success of the Standard. Fires caused by smoking materials declined approximately 81 percent from 27,500 fires in 1980 to 5,300 fires in 1998. In 1980 cigarettes caused about 48 percent of bedding fires. In 1998, cigarettes caused 31 percent of bedding fires.

Mattress fires caused by small open flames were not addressed in the Standard and continue to be a serious concern. Traditional small open flame sources are candles, matches, and lighters. Other small open flame heat sources include heat escaping from fueled equipment, molten material, short circuit arcs, and heat from overloaded equipment. In comparison to cigarette fires, open flame fires accounted for about 28 percent of mattress fires in 1980 but

accounted for about 39 percent in 1998. In 1991, the proportion of all small open flame fires first exceeded those caused by cigarette ignition.

It is important to note that, although mattress/bedding fires involving open flame ignition sources declined overall by about 70 percent, fire related deaths declined only 53 percent. According to CPSC data, in 1980, mattress or bedding items were the first to ignite in about 58,600 residential fires that resulted in 840 deaths, 3,090 injuries and \$235.4 million in property damage. In comparison, in 1998, mattress or bedding items were the first to ignite in about 18,100 residential fires that resulted in 390 deaths, 2,160 injuries and \$208.3 million in property damage (Hiser, 2000).

In summary, mattress fires caused by small open flame sources, such as matches, candles and lighters, and additional small open flame fires continue to be a significant cause of fire and fire related deaths and injuries. Although much was known about the circumstances of cigarette ignited mattress and bedding fires, the scenarios of open-flame ignited mattress and bedding fires were not clearly understood. In order to address the risk of small open flame ignited mattress fires, an improved understanding of the hazard as it exists in real-life was needed to develop meaningful research programs and effective standards. This memorandum reviews the processes used to gather information and explains the development and preliminary findings of current flammability research.

### **Field studies**

Because limited data were available regarding the nature of open-flame ignited bedding fires, two separate studies were conducted in an attempt to gain a more thorough understanding of mattress fire scenarios. The CPSC conducted an in-depth field study of all reported mattress and bedding related fires in which field investigators obtained detailed information by working with fire departments. In a separate study funded by the Sleep Products Safety Council (SPSC) and the National Association of State Fire Marshals (NASFM), an investigation of every bedding related fire in four select cities, New York, Chicago, Seattle and Houston, was conducted.

The two separate studies found similar results. Both studies found that the bedding is the first item to ignite in about two-thirds of the cases, while the mattress is ignited directly by open-flame in about one-third of the cases. They also found that the fire has already developed to a considerable size before the mattress is involved. The studies found open-flames to be a significant source of ignition and found that about two-thirds of the cases were caused by children 14 years old and younger playing with matches, candles and lighters.

### **Chairman's Roundtable**

In 1998, the Chairman of the CPSC hosted a roundtable meeting with key industry members to discuss current existing projects, current findings and future plans related to the understanding of mattress and bedding related fires. The meeting provided a chance for associations, industry members and organizations to share experiences, technical background, current concerns and future objectives in an open forum. Industry members discussed resolutions to explore the possibility of improving mattress resistance to open-flame ignition sources. Industry members agreed that a clear understanding of the problem, desired

performance objectives, and technical means to meet the objectives would need to be thoroughly evaluated in order to develop an effective test method and standard.

### **Current Flammability Research NIST Research, "Fire Safety Assessment for Mattresses"**

The development of a test method and standard for reducing the risk of mattress fires due to open flame ignition is a complex and comprehensive project. The Sleep Products Safety Council (SPSC), an affiliate of the International Sleep Products Association (ISPA) which focuses on promoting activities to reduce hazards associated with sleep products, began working with the National Institute of Standards and Technology (NIST) to address the fire hazard of mattresses by initiating a scientifically approached research program. The first phase of the research program, known as Flammability Assessment Methodology for Mattresses-Phase 1, involved four main objectives.

#### Phase 1

##### Initial evaluation of bedding products

The first objective of the study was focused on the fire behavior of bedclothes and involved characterizing the fire behavior of bedding products typically used in residential settings. In residential fire scenarios, the bedclothes are most likely to be the item first ignited and serve as a magnifier for a small open flame. Twelve combinations of bedclothes intended to represent commonly used items were selected. The combinations ranged from light, consisting of two sheets and a pillow, to heavy, consisting of a mattress pad, two sheets, blanket, heavy comforter and pillow. Each of the twelve combinations was placed on an inert fiberglass mattress and ignited. The heat release rate and fire spread rate was measured for each combination. The measured peak heat release rates of the bedclothes combinations ranged from 50kW to about 200kW. A 200 kW fire is a much larger fire than a match, candle or lighter ignition source but not large enough to create flashover conditions (flashover occurs when a fire becomes so intense that all exposed surfaces ignite nearly simultaneously, and quickly spread through the structure).

##### Characterization of the heat impact

In order to characterize the heat impact imposed on the surface of a mattress by the typical combinations of bedclothes, six of the twelve bedding combinations were selected and placed on an inert mattress consisting of a twin bed size frame covered with a thin metal foil. The six bedding combinations were selected to cover a range of performance, from moderate to most intense ignition threat. After ignition of the bedding, the heat impact on the mattress from the bedding was measured using a thermal-imaging process. Measurements of heat flux, duration, and affected location were taken. Interpretation of the measurements focused on the maximum values of the entire burn period in order to provide the maximum impact subjected to a mattress. The data showed that distinctly different burning conditions existed on the top and side of the mattress. More severe conditions were observed on the mattress top when compared to the side.

### Design of gas burners

The third objective in the study was to develop testing equipment that would consistently simulate the typical heat impact imposed on a mattress by bedding products. The importance of consistent testing equipment is necessary for providing controlled and reproducible results. Based on the data collected from the study of the bedclothes, two gas burners were developed to simulate burning bedding. Since two different burning conditions were exhibited on the side and top of the mattress, two different gas burners were developed. One burner simulated the heat impact observed on the top of the mattress and the other on the side of the mattress. The burners were designed to impose a fixed heat flux for a period determined by a time delay relay. The heat flux of the top surface burner is  $65 \text{ kW/m}^2$  with a duration time of either 45 seconds or 70 seconds. In comparison, the heat flux of the side surface burner is  $50 \text{ kW/m}^2$  with a duration time of either 25 seconds or 50 seconds. Both a short duration exposure time and a long exposure time were chosen to cover the range of collected data. A short exposure time was selected as one case and a long exposure time was chosen as a second, more severe exposure condition. Both the heat flux and duration levels were derived from the measurements on the bedclothes.

### Tests of mattresses using gas burners

The final objective was to test the gas burners and ensure their ability to produce results that correlated with actual tests of burning bedding. The burners were tested on five different types of mattresses. One mattress represented current residential technology. The other four mattresses were constructed with different types of potential fire resisting components, including modified fibers, barrier fabrics and treated foams. In four out of the five cases, the fire behavior caused by the gas burners correlated with the fire behavior seen in the fires caused by the bedclothes. The one exception that was seen in bed clothing induced fires and not with the burners, involved a phenomenon known as internal over-pressurization of the mattress. Internal over-pressurization occurs when a flammable gas mixture builds up within the mattress causing rupturing of the mattress seams and allowing fire penetration into the interior and is due to a deflagration wave that flashes through a mixture of pyrolysis gases and air in the mattress interior.

The research conducted during Phase 1 provided very useful information regarding fires involving mattresses and their interaction with bed clothing. Burning bed clothing was shown to produce a large fire on its own reaching a heat release rate of up to  $200 \text{ kW}$ . Mattresses without bed clothing, however, were shown to produce fires large enough to cause room flashover adding to the complexity of the hazard. In addition, the research enabled the development of gas burners that appear to successfully simulate most burning bedding conditions. The exception involved the internal deflagration and over-pressurization phenomenon exhibited in some mattress constructions. Mattresses with this behavior should be avoided or designed to resist rupturing during a fire. The testing also showed how mattress materials and construction techniques can be utilized to provide improved mattress fire behavior.

### Phase 2

It is clear that much was gained from Phase 1 of the Flammability Assessment Methodology for Mattresses, but in order to achieve a more complete understanding of the fire scenario involving mattresses and bedding, another phase of testing was required. Phase 2, currently in its early stages, is focused on two primary areas of study. One is to assess the affect