

# The Fire-safe Cigarette: A Burn Prevention Tool

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Cigarettes are the most common ignition source for fatal house fires, which cause approximately 29% of the fire deaths in the United States. A common scenario is the delayed ignition of a sofa, chair, or mattress by a lit cigarette that is forgotten or dropped by a smoker whose alertness is impaired by alcohol or medication. Cigarettes are designed to continue burning when left unattended. If they are dropped on mattresses, upholstered furniture, or other combustible material while still burning, their propensity to start fires varies depending on the cigarette design and content. The term "fire-safe" has evolved to describe cigarettes designed to have a reduced propensity for igniting mattresses and upholstered furniture. Legislative interest in the development of fire-safe smoking materials has existed for more than 50 years. Studies that showed the technical and economic feasibility of commercial production of fire-safe cigarettes were completed more than 10 years ago. Despite this, commercial production of fire-safe smoking materials has not been undertaken. The current impasse relates to the lack of consensus on a uniform test method on which to base a standard for fire-safe cigarettes. Although the fire-safe cigarette is a potentially important burn prevention tool, commercial production of such cigarettes will not occur until a standard against which fire-starting performance can be measured has been mandated by law at the state or federal level. The burn care community can play a leadership role in such legislative efforts. (*J Burn Care Rehabil* 2000;21:164-70)

The cardiovascular and cancer risks associated with cigarette smoking are well appreciated. A lesser-known fact is that cigarettes and other smoking materials are also a major contributing factor for injury or death caused by fires. Simply stated, house fires are the major cause of fire- and burn-related deaths, and

cigarettes are the major source of ignition in house fires. House fires comprise only one fourth of the incidents reported to fire departments but are the cause of up to 79% of fire-related injuries and 80% of fire-related deaths.<sup>1-14</sup> House fires are the cause of less than 5% of burn center admissions but are the cause of more than 45% of burn-related deaths.<sup>6,15</sup>

Smoking materials, almost always cigarettes, are the most common ignition source for fatal residential fires.<sup>1,4,7,8,13,16,17</sup> Ninety-five percent of all fire-related deaths caused by smoking materials occur in the home.<sup>18</sup> Fires started by smoking materials cause

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approximately 1000 deaths and 3000 to 4000 serious injuries each year.<sup>8,12,17-21</sup> Thirty-nine percent of the victims killed in such fires are not the smokers themselves but are sleeping in the same house or an adjacent apartment when a fire is started by a careless smoker.<sup>8,16</sup> The total cost of deaths, injuries, and property damage caused by cigarette-ignited fires is estimated by the federal government to be \$4 billion each year.<sup>21</sup>

When all factors that contribute to deaths caused by fires are analyzed, one point is striking. Many fatal fires are caused by the ignition of a bed, chair, or sofa by a cigarette when an individual is smoking in bed, using alcohol, or both.<sup>1,7,13,17,22,23</sup> In a classic study, Birky et al<sup>7</sup> demonstrated that this scenario was the cause of 47% of all fatal fires that occurred during a 6-year period in the state of Maryland. More recently, Barillo and Goode<sup>11,24</sup> demonstrated that in 44% of 727 fire fatalities in New Jersey, there was evidence of alcohol or drug use and that when the cause of the fire was known, cigarettes were the leading cause of ignition.

Injury or death caused by a fire requires the interaction of human behavior, a source of ignition, a source of oxygen, and a source of fuel.<sup>3,11</sup> Injury prevention requires the removal or modification of one or more of these factors.<sup>3,24</sup> Because many smoking-related fire fatalities involve alcohol use, modification of human behavior is unlikely to be successful.<sup>17</sup> Likewise, it is impractical to completely remove the fuel source (mattresses or furniture), although both federal legislation and voluntary industry guidelines have made mattresses and upholstered furniture more fire-resistant.<sup>18,25</sup> The most practical method to reduce fire-related fatalities is to modify the ignition source (cigarettes).

Cigars and pipes usually stop burning when they are left unattended. Cigarettes, on the other hand, continue to burn even when they are not being inhaled. The term "fire-safe" refers to a cigarette designed to demonstrate a reduced propensity for igniting mattresses and upholstered furniture. The concept of a fire-safe cigarette is endorsed by multiple health and safety organizations, including the American Burn Association, the American Medical Association, the National Fire Protection Association, the International Association of Fire Chiefs, the International Association of Firefighters, the National Volunteer Fire Council, and the American Public Health Association.<sup>17,25</sup> Despite these endorsements, commercial production of fire-safe cigarettes has not been undertaken and is unlikely to occur in the absence of a legislative mandate. The current impediment to fire-safe cigarette legislation is

a lack of consensus on a uniform test method on which to base a standard for fire-safe cigarettes.

In the past year, legislative interest in the development of a fire-safe cigarette has revived at both the federal and state levels. Active promotion by a broad coalition of organizations and individuals is needed to bring about the passage of legislation that mandates a cigarette fire-safety standard at either the federal or the state level. The purpose of this article is to inform the burn community of the historical and technical aspects of this issue and to solicit support for legislation that will lead to the commercial development of fire-safe cigarettes.

## THE FIRE-SAFE CIGARETTE: LEGISLATIVE HISTORY

Legislative interest in a fire-safe cigarette dates back to the late 1920s when US Congresswoman Edith Nourse Rogers of Massachusetts introduced a bill that called for the development of a more fire-safe cigarette as a method of preventing forest fires.<sup>17,25</sup> The concept reemerged as part of the consumer safety movement of the 1970s and received a major boost when the Trauma Foundation in San Francisco commissioned an in-depth study of the issue in 1978. Shortly after that study was published in the popular press,<sup>26</sup> a fire started by a dropped cigarette killed 5 young children and their parents in the suburban Boston district of Massachusetts Congressman Joseph Moakley. As a result, Representative Moakley developed a special interest in cigarette fire safety, and 5 months later he introduced a bill that called on the US Consumer Product Safety Commission to regulate cigarettes as a fire hazard. Representative Moakley remains the prime congressional sponsor of fire-safe cigarette legislation.

Representative Moakley's first bill served to educate and to generate support for the idea of safer smoking materials among public health and fire service organizations at the state and national level. Within 2 years, bills that mandated "self-extinguishing" cigarettes were also introduced in several state legislatures and were almost passed in Oregon, Minnesota, and New York. In 1980, California State Senator John Garamendi (D) presented legislation that required the development of standards for testing and the development of a fire-safe cigarette. It was passed in the Senate but was defeated in the State Assembly.

The establishment of a cigarette fire-safety standard in a single state could potentially disrupt the entire national production and marketing systems of tobacco companies. Consequently the tobacco industry, to

**Table 1.** Composition of the technical study group\*

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Medical interests
American Burn Association
American Medical Association
American Public Health Association
Fire service
International Association of Fire Chiefs
National Fire Protection Association
Federal government
Consumer Product Safety Commission
National Cancer Institute
Federal Trade Commission
US Fire Administration
National Bureau of Standards
Tobacco industry
Philip Morris
American Tobacco
Lorillard
R.J. Reynolds
Furniture industry

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\*The technical study group included 1 representative from each group.

avoid piecemeal state legislation, acquiesced to the federal Cigarette Safety Act of 1984 (PL98-567). This act established the 15-member Technical Study Group to oversee federally funded research performed by the National Bureau of Standards (the predecessor of the National Institute of Standards and Technology) that examined the technical and commercial feasibility of the development of fire-safe cigarettes. The Technical Study Group included representatives from the tobacco and furniture industries, the federal government, medical interests, and the fire service (Table 1). In 1987, at the conclusion of the research, the Technical Study Group released a final report, which stated that it was technically feasible to produce a cigarette with a significantly reduced propensity for igniting upholstered furniture<sup>20</sup> and that the necessary changes in cigarette design would not have a major impact on cigarette cost.<sup>17</sup> The final report also called for more study in such areas as toxicity and economic impact.<sup>19</sup>

This report stimulated further political maneuvering before "more study" was mandated by the Fire-Safe Cigarette Act of 1990 (PL 101-352). In addition to funding the economic impact studies called for in 1987, this measure called for the Center for Fire Research at the National Institute of Standards and Technology to develop a method for testing cigarette fire-safety performance. The 15-member Technical Study Group from the 1984 legislation was reconvened and renamed the Technical

Advisory Group.<sup>20</sup> The Technical Advisory Group released a final report in 1993 that described 2 cigarette fire-safety test methods developed by the Center for Fire Research called the "mock-up ignition method" and the "cigarette extinction method."<sup>19</sup> These test methods were never adopted because the 4 tobacco industry representatives on the Technical Advisory Group challenged the validity of the methods. The remaining 11 members of the Technical Advisory Group, who represented federal agencies, the furniture industry, the fire service, and medical organizations, all voted to endorse these test methods.<sup>19</sup>

After the release of the report by the Technical Advisory Group, Congressman Moakley introduced the Fire-Safe Cigarette Act of 1994. This bill called on the US Consumer Product Safety Commission to establish a fire-safe cigarette standard. Such a standard could ostensibly be applied to the test methods described in the 1993 report or to others refined in further research. The bill also would have prevented advance stockpiling of noncompliant cigarettes and allowed states to pass even more stringent standards. Passage of this act would have been a major step; it might have been the last legislation on the road to the application of a fire-safety standard to commercially produced cigarettes. However, changes in congressional leadership in the 1994 elections reflected a voter mandate for "less government" that stalled cigarette legislation at the national level. Five years later, sensing a moderating mood in the country, Representative Moakley reintroduced his bill. On March 16, 1999, the Fire-Safe Cigarette Act of 1999 (HR 1130) was introduced and referred to the Committee on Commerce. This bill would direct the Consumer Product Safety Commission to issue a cigarette fire-safety standard within 18 months of passage. At that time, manufacture or importation of cigarettes not in compliance with the safety standard would be prohibited.

In the absence of federal legislation, fire-safe cigarette legislation has reappeared at the state level. In December 1997, a fire in San Francisco caused the deaths of 5 children and their 42-year-old grandmother. The cause was traced to a smoldering cigarette. Assemblywoman Carole Migden (D), in direct response to this disaster, presented Assembly Bill 2200 to the State Legislation of California in February 1998. Assembly Bill 2200 would have required that the State Fire Marshal develop standards by June 1, 1999, and that all cigarettes sold in California meet those standards by January 1, 2000.

Despite the support of the California Firefighters' Association, the California Fire Chiefs' Association, The Trauma Foundation, and the Children's Advocacy Institute, this legislation introduced to the State Assembly is currently buried in Committee.

As a result of the amount of publicity that Assembly Bill 2200 initially received, a small study was started in July 1998 at the University of California-Davis Regional Burn Center to identify whether there were significant data to support the need for such a law. Results of the 18-month retrospective analysis showed that 14.5% of all burn center admissions were cigarette related,<sup>27</sup> which was the fourth highest cause of injury, after flammable liquids, open flame, and scalds.

### THE FIRE-SAFE CIGARETTE: TECHNICAL ASPECTS

The *burn rate* of a cigarette, defined as the change in length or mass with time, is determined by multiple factors, including the circumference of the cigarette, the packing density of the tobacco, the porosity of the paper, and the presence or absence of a filter.<sup>25,28</sup> Cigarette manufacturers often add accelerants such as citrate, phosphate, or calcium carbonate to cigarette paper to maintain continuous burning when the cigarette is not being inhaled.<sup>25,28</sup> Modification of any of the above factors or deletion of accelerants will result in a slower-burning cigarette, with presumably less propensity to start a fire. The myriad approaches to this problem are reflected by almost 100 patents that have been issued worldwide for methods that are supposed to render a cigarette fire-safe or self-extinguishing.<sup>25</sup> A report issued in 1981 by the National Bureau of Standards documented that the potential to ignite furniture varied considerably between different cigarette brands on the market at the time,<sup>16</sup> which demonstrated the effect of different manufacturing techniques.

In 1974, a study performed by Arthur D. Little, Inc, suggested that if cigarettes self-extinguished within 10 minutes of being placed on furniture, ignition would not occur.<sup>25</sup> In the initial efforts to reduce the risk of fires caused by cigarettes, it was therefore assumed that the answer lay in requiring cigarettes to self-extinguish quickly, and the first federal legislation in the early 1980s simply required that cigarettes self-extinguish within a specified period. After further study, it was discovered that some cigarettes could burn their entire length when placed on furniture without causing ignition. The term *fire-safe*

evolved to characterize what the National Institute of Standards and Technology now defines as "cigarettes demonstrating a reduced propensity for igniting mattresses and upholstered furniture."<sup>20</sup> In this broader approach, the fact that many factors in addition to burning time influence how cigarettes start fires is more accurately recognized. Rather than simply addressing burning time, the scientific effort is now focused on the development of a reliable standard for the testing and evaluation of the overall fire-starting propensity of cigarettes.

The Cigarette Safety Act of 1984 (PL98-567) provided \$3 million for the study of the technical and economic feasibility of producing fire-safe cigarettes. This research, supervised by the Technical Study Group and performed by the National Bureau of Standards, examined the propensity of cigarettes to ignite furniture with the use of small-scale furniture mock-ups.<sup>17</sup> Researchers examined 12 brands of commercial cigarettes that represented different designs and market shares and 41 types of experimental cigarettes to evaluate differences in tobacco type or density, circumference, paper porosity, and citrate (accelerant) content.<sup>17</sup> Cigarette companies produced the experimental cigarettes used for the study. The combination of low tobacco density, smaller diameter, lack of citrate, and low paper porosity resulted in an experimental cigarette that failed to produce ignition in 20 furniture mock-up trials.<sup>17</sup> Nicotine, carbon monoxide, and tar measurements of the experimental cigarettes were performed by the Federal Trade Commission and were found to be no greater than 2 popular cigarette brands on the market at the time of the study.<sup>17,20</sup>

A second task assigned under the 1984 act was an economic analysis. Thirty different economic impact analyses and sensitivity tests were performed on the basis of 5 hypothetical cigarette modifications: change in tobacco density, chemical additives, change in cigarette circumference, change in paper weight, and change in paper porosity.<sup>29</sup> Although all of the modifications had some impact on tobacco farming, cigarette production, tax revenue, or employment, the researchers concluded that, overall, the 5 modifications would cause only a small percentage change in the supply price of cigarettes. Two modifications were predicted to minimally increase production costs, 2 modifications were predicted to minimally decrease production costs, and the fifth modification was predicted to be approximately neutral in cost consequences.<sup>29</sup>

The Technical Study Group concluded that it was

**Table 2.** Health effects assessment plan for fire-safe cigarettes developed by the Consumer Product Safety Commission in response to the Fire-Safe Cigarette Act of 1990 (PL 98-567)\*

Tier I: chemical analysis of smoke
Acidity and reduction/oxidation potential, carbon monoxide, hydrogen cyanide, nitrogen oxides, aldehydes, volatile hydrocarbons, volatile nitrosamines, particulate matter (tar), catechols, nicotine, phenols, polynuclear aromatic hydrocarbons, and tobacco-specific nitrosamines
Tier II: in vitro tests
<i>Salmonella</i> mutagenicity (Ames' assay) and mouse embryo fibroblast cell transformation assay
Tier III: indicators of human smoking behavior
Levels of cotinine and carbon monoxide in human subjects, smoker topography (puff volume, frequency, and draw velocity)
Tier IV: in vivo tests
Mouse inflammatory lung response, hamster respiratory tract carcinogenicity, mouse skin-painting carcinogenicity

\*Estimated cost per cigarette design tested (1990-1993): entire series, \$330,000; tier I and tier II, \$6,900.

"technically feasible and may be commercially feasible to develop cigarettes that will have a significantly reduced propensity to ignite upholstered furniture or mattresses."<sup>17</sup> The group recommended the development of a standardized ignition propensity test method and noted variability in different lots of fabrics and stuffings used in furniture mock-ups.<sup>17</sup>

The need for a standard test method was addressed by the Fire-Safe Cigarette Act of 1990 (PL 101-352). This legislation directed the National Institute of Science and Technology (NIST) to develop a standard test method to determine cigarette ignition propensity, to compile performance data for cigarettes with this standard test method, and to conduct studies on mathematical modeling of ignition physics.<sup>21</sup> The Consumer Product Safety Commission was directed to study the social costs of cigarette-ignited fires, to collect data on the characteristics of cigarettes, products ignited, and smokers involved in fires, and to develop information on the changes in toxicity and health effects that might occur with a fire-safe cigarette design.<sup>21</sup>

The toxicology issue was researched by an expert panel convened by the Consumer Product Safety Commission in conjunction with the Department of Health and Human Services. The panel developed 4 sequential tiers of in vitro and in vivo tests adequate to establish that the design changes needed to make a cigarette fire-safe would not increase the other known health hazards of cigarettes (Table 2). The cost to implement the entire testing sequence was estimated at \$330,000 per cigarette design evaluated.<sup>21</sup> Budgetary restrictions limited actual testing to parts of the first 2 tiers at a cost of \$6,900 per cigarette design.<sup>21</sup> Five cigarette types were successfully tested, including 2 commercial brands, 2 experimental cigarettes, and 1 reference cigarette,<sup>21</sup> which validated the methodology and cost estimates developed by the expert panel.

Two test methods for cigarette ignition propensity were developed by NIST. In the mock-up ignition method, 3 variations of a layer of cotton duck fabric over urethane foam padding are used to simulate the construction of upholstered furniture. The outcome is measured as ignition or nonignition of the fabric by the test cigarette.<sup>30</sup> In the cigarette extinction test method, multiple layers of filter paper are used as a substitute for furniture fabric. The outcome is measured as full-length burning or self-extinguishment of the cigarette. Both methods were used to test 14 best-selling brands of commercial cigarettes that comprised 38% of the 1990 market and 6 other commercial brands, each of which had at least 2 physical characteristics associated with decreased fire propensity, that comprised less than 1% of the market. The 14 popular brands were all similar in fire-starting characteristics. With 1 exception, all of the 14 brands ignited the test fabrics in all tests.<sup>21</sup> In contrast, 5 of the 6 commercial cigarette brands that had fire-safe characteristics showed decreased ignition propensities on the standard tests.<sup>30</sup>

For the measurement of repeatability and reproducibility, both the mock-up test method and the cigarette extinction test method were independently evaluated at 9 private and government laboratories. The ratio of repeatability to reproducibility limits of both methods was considered to be within the range of other fire test methods used for fire regulations.<sup>30</sup>

The ignition propensity test methods generated considerable controversy. Although 11 members of the Technical Advisory Group voted to endorse the test methods, the 4 members who represented the cigarette industry voted against adaptation; they claimed that the test methods did not simulate real-life conditions.<sup>21</sup> Although the test chamber used for the mock-up ignition method was an adaptation of a cigarette-industry model, the 4 members who

represented the cigarette industry claimed that the effects of airflow were not properly accounted for.<sup>21</sup> The choice of cotton duck fabric was criticized as unrepresentative of furniture manufacturing practices,<sup>21</sup> although subsequent research on a wide variety of upholstered fabrics indicated that cotton duck was an appropriate choice.<sup>31</sup> Independent research funded by the cigarette industry to measure the fire-starting propensity of popular cigarette brands yielded results that were different from the NIST data.<sup>21</sup> The interlaboratory reproducibility studies were also criticized. The lack of consensus on a standard ignition propensity test method has hindered further efforts at fire-safe cigarette legislation.

A final technical point is that the tobacco industry is aware of the feasibility of the manufacture of fire-safe cigarettes. As early as 1939, R.J. Reynolds advertised "Slower-Burning Camels" with the claimed advantage of "more puffs per pack."<sup>25</sup> In March 1994, the television program "60 Minutes" aired a segment entitled "Up in Smoke" that detailed efforts of the Philip Morris Company to develop a fire-safe cigarette in 1980.<sup>20</sup> This research had the code name "Project Hamlet," which referred to a corporate inside joke "to burn or not to burn."<sup>20</sup> Unmarked packs of Project Hamlet cigarettes were evaluated by taste testers (77 smokers) in 1987 and reported to be indistinguishable from the commercial Marlboro brand.<sup>20</sup>

## DISCUSSION

It is clear that production of a fire-safe cigarette is both technically and economically feasible and that certain cigarette brands, by virtue of design or physical characteristics, already demonstrate fire-safe properties. Beyond this, the issue remains complex. In this regard, several points need to be made.

First, the passage of fire-safe cigarette legislation is an issue related to burns and fire prevention and not an antismoking or antitobacco issue. It is not the intent of present or past fire-safe cigarette legislation to limit the rights of those who have chosen to smoke or to impose additional health standards on the tobacco industry.

Second, adoption of a standard method to quantify the potential of cigarettes to ignite mattresses and upholstered furniture is the only obstacle that remains before commercial production of fire-safe cigarettes can be undertaken. Although the benefits and shortcomings of the 2 NIST test methods can be debated, it is clear that nothing further will be accomplished until a standard test method is agreed on or adopted. Adoption of a uniform test method

could be based on a voluntary industry standard, on a standard developed by a third party such as the National Fire Protection Association or the American Society of Testing and Materials, or on a standard developed by the federal government.

Third, federal legislation of one standard is preferable to a patchwork of individual state regulations, which would significantly disrupt the commercial production and marketing of cigarettes.

The fourth point to consider is liability. If the tobacco industry concedes that cigarettes are prone to start fires and that safer cigarette technology has existed since the 1980s, one might expect to see litigation initiated by people with injuries that resulted from cigarette-ignited fires.<sup>19,20</sup> Liability relief may need to be addressed by any final legislation that mandates the production of fire-safe cigarettes. Again, federal legislation, rather than state legislation, would be the most appropriate forum.

There are no cigarettes expressly designed to be fire-safe currently being produced commercially. Because of the potential of testing technology and the continuing public concern about the hazards associated with smoking, enactment of a fire safety standard that would apply to all cigarettes manufactured or sold in the United States may be only a matter of time. Burn care providers can facilitate this process by advocating and supporting federal legislation that mandates a standard cigarette test method and prohibits the manufacture or importation of cigarettes not in compliance with this standard. In the absence of a uniform federal standard, the same advocacy should be given to legislative efforts at the state or local level.

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