RANGE HOOD FIRE EXTINGUISHING SYSTEMS IN U.S. MARINE CORPS FAMILY HOUSING

EXECUTIVE DEVELOPMENT

BY: T. Kevin King, P.E.
Manager, Fire Protection Programs
Headquarters, U.S. Marine Corps
Washington, District of Columbia

An applied research project submitted to the National Fire Academy
as part of the Executive Fire Officer Program

March 1998

Abstract

The U.S. Marine Corps policy since 1990 has been to install kitchen range hood fire extinguishing systems in family housing construction. Recently, the Commandant of the Marine Corps proposed eliminating this policy in an effort to reduce costs associated with the family housing construction program. Unfortunately, there was little current analysis or literature that supported the need for the range hood fire extinguishing systems.

The purpose of this research was to determine if the U.S. Marine Corps should continue installing range hood fire extinguishing systems in family housing construction. Historical and evaluative research methods were used to answer the following questions:

1. What is the fire loss history from range fires in U.S. Marine Corps family housing?

2. Does the literature support the installation of range hood fire extinguishing systems in family housing?

3. What is the cost of range hood fire extinguishing systems?

4. Does the installation of residential sprinklers have an affect on the need for range hood fire extinguishing systems in family housing?

Literature reviews and interviews conducted for this research indicated range fires in family housing were a concern within the military services and throughout the U.S. However, there was little support for installing range hood fire extinguishing systems and no national standard or code was mandating the systems. A fire loss data analysis indicated range fires were significant within the U.S. Marine Corps family housing but were much less significant when compared to all the U.S. Marine Corps fire losses. A net present cost analysis indicated residential sprinklers and no protection were substantially less expensive than range hood fire extinguishing systems on range fires.

The research recommended the U.S. Marine Corps discontinue installing range hood fire extinguishing systems in family housing construction. Additional recommendations included expanded public fire education, continued monitoring and further validation of residential sprinkler performance on range fires.

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Introduction

In 1990, the U.S. Marine Corps formally established a policy of providing kitchen range hood fire extinguishing systems in their family housing construction projects. The range hood fire extinguishing systems were included as part of the U.S. Marine Corps residential sprinkler policy to address the high incidence of unattended cooking fires in family housing. In 1995, the U.S. Marine Corps began a significant review of their family housing construction projects with an emphasis on reducing the costs. The reviews were necessary due in part to reduced housing appropriations from Congress and the potential for privatization of the family housing program. One of the items identified during the reviews was the range hood fire extinguishing systems. Many in the U.S. Marine Corps and the U.S. Department of Defense questioned the need for the range hood fire extinguishing systems given the apparent excellent fire safety record in the U.S. Marine Corps family housing. Unfortunately, there was no current analysis or standard to defend or support the need for the range hood fire extinguishing systems. As a result, the U.S. Marine Corps could not make an informed decision about the need for the range hood fire extinguishing systems.

The purpose of this research was to determine if the U.S. Marine Corps should continue installing range hood fire extinguishing systems in family housing construction projects. Historical and evaluative research methods were employed to answer the following questions:

1. What is the fire loss history from range fires in U.S. Marine Corps family housing?

2. Does the literature support the installation of range hood fire extinguishing systems in family housing?

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Background and Significance

In the mid 1980's, the U.S. Marine Corps began focusing on family housing as one of it's most pressing fire problems. The U.S. Marine Corps initially addressed this problem through the installation of residential sprinkler systems and was the first U.S. military service to install residential sprinklers in an entire family housing complex (W. J. Patterson, personal communication, October 15, 1985). In 1988 the Commandant of the Marine Corps reviewed the fire protection requirements for a new family housing project at Camp Pendleton, California. The review identified residential fires as the U.S. Marine Corps fire problem and recommended the installation of residential sprinkler systems to address the problem. However, for the first time, the review also recommended the installation of range hood fire extinguishing systems to combat unattended cooking fires. Unattended cooking fires were identified as a leading cause of fires and property loss in U.S. Marine Corps residences with an average of 100 fires each year and losses averaging $800 to $900 per fire. The review stated range hood fire extinguishing systems would cost in the neighborhood of $300 with significant unit cost reductions for large quantity purchases.

As a result of the Camp Pendleton project, the U.S. Marine Corps formulated a policy requiring residential sprinklers and range hood fire extinguishing systems in all family housing construction projects. While the proposed policy was often the subject of debate within the U.S. Marine Corps, the other military services and the U.S. Department of Defense, the Commandant of the Marine Corps formally adopted the policy in 1990.

From 1990 through 1995, the U.S. Marine Corps installed residential sprinklers and range hood fire extinguishing systems in approximately 2,500 family housing units. This represented approximately ten percent of the U.S. Marine Corps family housing inventory. The estimated cost of both fire protection systems was $3000 (1993 dollars) per unit although there was not a separate budget line for the range hood fire extinguishing systems (U.S. Department of the Navy, 1992). Thus, the cost to provide residential sprinkler systems and the range hood fire extinguishing systems for the remaining U.S. Marine Corps housing inventory was estimated at $67 million (1993 dollars). The U.S. Marine Corps was successful in defending the cost of the residential fire protection systems and increased funds were appropriated from Congress to pay for the systems.

By 1995, the U.S. Marine Corps residential fire protection program was coming under increased scrutiny. The Fire Administration Authorization Act of 1992 mandated sprinkler protection in multi-family housing construction projects by 1995, but did not include any requirements for range hood fire extinguishing systems. The

U.S. Department of the Air Force (1993) reversed it's policy on providing range hood fire protection systems in high-rise multi-family housing units and eliminated the requirement for all range hood fire extinguishing systems. A U.S. Marine Corps Commanding General and a senior U.S. Department of the Navy official questioned the need for the residential fire protection systems during a tour of a family housing construction project (T.A. Braaten, personal communication, January 12, 1995). In 1996 the U.S. Department of Defense recommended eliminating both the residential sprinklers and the range hood fire protection systems from the fiscal year (FY) 1998 family housing construction program. Finally, the U.S. Department of Defense initiated a number of studies to reduce the infrastructure support costs of the military services. As a result of the studies, all the military services were directed to reduce the cost of the family housing construction program and consider privatization of family housing to reduce costs. The U.S. Marine Corps identified the residential fire protection systems as a possible area for savings if the residential sprinklers or range hood fire protection systems could be eliminated.

In response to the inquiries, the Commandant of the Marine Corps (1995) defended the residential sprinkler policy. The sprinklers were identified as a quality of life issue that significantly reduced a person's chance of dying in a residential fire. The cost for sprinklers was quickly identified and was substantially less than estimated. Although there were only a few incidents, sprinklers had positive track record of containing fires, preventing injuries and reducing property damage in family housing fires. Finally, the sprinkler policy met the requirements of the Fire Administration Authorization Act of 1992 that eliminated the need for additional fire protection measures in family housing. As a result, the Commandant of the Marine Corps (1997) approved the residential sprinkler policy for multi-family housing construction projects.

Unfortunately, the U.S. Marine Corps could not provide the same defense for the range hood fire extinguishing systems. There was inconsistent data on the costs of the systems, especially the recurring costs. Also, there were no national laws or standards that mandated the range hood fire extinguishing systems and no readily available data on the effectiveness of the systems. The U.S. Department of the Air Force (1993) had conducted a life cycle cost on range hood fire extinguishing systems that identified a payback period of over 200 years. As a result, the Commandant of the Marine Corps (1995) proposed eliminating the requirement for the range hood fire extinguishing systems unless significant justification was presented to retain the systems.

This research aims to collect and analyze the data on the range hood fire extinguishing systems and provide a recommendation on the need for the systems in U.S. Marine Corps family housing. The Commandant of the Marine Corps can then make an informed decision on the range hood fire extinguishing systems for family housing construction.

This research is relevant to the Executive Development course because it addressed a service quality issue and required a problem solving approach. These were two of the major topics addressed in the Executive Development course.

Literature Review

Surprisingly, very little literature was found relating to range hood fire extinguishing systems outside of the military services. For example, a search of kitchen and range hood fire extinguishing systems at the Learning Resource Center, National Emergency Training Center produced no matches in September 1997. However, there were a few studies, articles and correspondence regarding range hood fire extinguishing systems within the military services. There also were a number of studies, both within and outside the military, regarding the cooking fire problem in family housing. The literature review focused on four main areas for this research: the cooking fire problem in family housing, code and standard requirements for range hood fire extinguishing systems, range hood fire extinguishing system costs and range hood fire extinguishing system performance.

The Cooking Fire Problem in Family Housing

One of the earliest indications of the cooking fire problem within the military services was a 1988 report by McGill, Centrone, Stepetic, Walker and Sartain that evaluated stove-top automatic fire extinguishing devices for the U.S. Department of the Air Force. The report noted that 45 percent of the military family housing fires occur in the kitchen with cooking equipment involved in the ignition. As a result, the U.S. Air Force decided to "evaluate an automatic, independent, self-contained fire extinguisher to prevent large-scale damage to military family housing kitchens. The self-contained device would be located in the range hood, near the ignition source, to detect and suppress stove-top fires quickly, thereby minimizing fire and smoke damage to the housing unit" (McGill et al, 1988,

p.1). The evaluation was successful in developing a performance specification for the extinguisher that is currently used by the U.S. Marine Corps in designing the range hood fire extinguishing systems.

In 1989 Kirchner provided a staff brief to the Commandant of the Marine Corps on the unattended cooking fire loss and stove cooking equipment fire loss within the U.S. Department of Defense. The brief was based on fire loss data from the Naval Safety Center and covered the period from FY1983 through FY1987. The analysis indicated that U.S. Department of Defense fire departments responded to an average of 158 stove cooking fires per year with an average loss of $1,739 per fire. No information was provided on the number of injuries or fire deaths from the stove fires, however the data did indicate there were 155 injuries and two fire fatalities from unattended cooking fires between FY1983 and FY1987.

In 1993 the U.S. Department of the Air Force conducted a substantial policy review and life cycle cost analysis of the kitchen range fire extinguishing systems installed in U.S. Air Force military family housing. As part of the analysis, the U.S. Air Force conducted a review of the kitchen fire losses in U.S. Air Force family housing from FY1984 through FY1991. The report indicated there were an average of 146 kitchen fires per year with an average loss per kitchen fire of $3,195 in then year dollars. There were no fire deaths and 220 injuries due to the kitchen fires. The report indicated there were approximately 137,000 military family housing units in the U.S. Air Force inventory so the kitchen fire rate was approximately 0.11 percent per family housing unit per year and the injury rate was approximately 0.02 percent per family housing unit per year. The report assumed kitchen ranges were responsible for all the kitchen fires.

The most recent analysis of the U.S. home (one and two family dwellings and apartments) cooking fires outside the military services was the annual U.S. Home Cooking Fire Patterns and Trends (Hall, 1997). The latest report covers the periods of 1980 through 1995 and indicated that cooking equipment fires are the leading cause of home fires and civilian injuries reported to U.S. fire departments. Cooking equipment fires accounted for nearly one-fourth all U.S. home fire injuries and the majority of home fires not reported to fire departments. Cooking fires placed sixth in 1995 for home fire fatalities and ranked fifth for direct property loss in home fires. Most injuries from cooking fires were the result of trying to control the fire although the majority of the cooking fire deaths took place when the victims were asleep. Unattended cooking was the major cause of home cooking fires accounting for over half the home cooking fires.

Hall (1997) indicated stoves were the major cause of fires, injuries and deaths in home cooking fires. Stoves caused an average of 80,000 fires, 230 deaths, 4200 injuries and $300 million in direct property loss per year from 1991 through 1995 (See Table 1).

The conclusions and recommendations from Hall (1997) focused on supervision of cooking as the most important step to avoid cooking fires. Further recommendations addressed loose fitting clothing, using cooking equipment properly, avoiding late night cooking and the need for expanded public education programs. Interestingly, the report did not recommend or address the need for range hood fire extinguishing systems.

Table 1

1991 - 1995 U.S. Home Stove Fires

Year	Stove Fires	Deaths	Injuries	Property damage (in millions)
1991	81,100	243	4,468	$377.4
1992	85,700	223	4,282	$258.6
1993	84,700	263	4,766	$344.0
1994	77,200	214	3,882	$264.6
1995	72,400	211	3,778	$248.4
Total	401,100	1154	21,176	$1,493.0
Average	80,220	231	4,235	$298.6

The previous studies and analysis of home cooking fires influenced this research by indicating these fires remain a concern both within the military and the U.S. The National Fire Protection Association (NFPA) report stated, "The trends suggest a problem that is declining in overall size, but slowly and not for injuries or property damage" (Hall, 1997, p.32). The most recent data within the military services is the 1993 report by the U.S. Department of the Air Force which indicated the U.S. Air Force suffers almost one-half a million dollars a year in property loss and 28 injuries a year from kitchen fires. While this is significant, it is not clear if this loss rate justifies the need for range hood fire extinguishing systems.

Codes and Standards

A review of the U.S. model building codes and life safety code did not identify any requirement for the installation of range hood fire extinguishing systems in family housing. The 1996 edition of the National Building Code (Building Officials and Code Administrators International), the 1997 edition of the Uniform Building Code (International Conference of Building Officials), the 1997 edition of the Standard Building Code (Southern Building Code Congress International) and NFPA Standard 101, 1997 edition, entitled "Safety to Life from Fire in Buildings and Structures" only require protection in commercial kitchen exhaust systems. NFPA Standard 96, 1994 edition, entitled "Ventilation Control and Fire Protection of Commercial Cooking Operations" is the only NFPA standard that requires fire extinguishing equipment for protection of cooking equipment. However, this standard only addresses commercial cooking equipment and specifically exempts single family residential usage (NFPA 96, 1994, p. 4).

Within the military, Military Handbook 1008C, 1997 edition, entitled "Fire Protection for Facilities Engineering, Design and Construction" contains the fire protection requirements for all the military services. As with the model building codes, there was no requirement for range hood fire extinguishing systems in family housing. Thus, the only current requirement for these systems in military family housing was contained in the U.S. Marine Corps Family Housing Management Manual (Commandant of the Marine Corps, 1991).

The lack of any requirement for range hood fire extinguishing systems was further exemplified in telephone interviews with J.P. Rouse (personal communication, February 6, 1998) and S.A. Scully (personal communication, January 2, 1998). Rouse stated there was no current requirement for the range hood fire extinguishing systems in either the military or private market. However, he was hopeful NFPA would add some language in the future given that cooking fires remain the leading cause of home fires. Scully also stated there was no code requirements for the

range hood fire extinguishing systems. Scully advised that the National Association of Home Builders was not recommending adding language to any code or standard which would require systems.

The review of the codes and standards clearly indicates range hood fire extinguishing systems have not been widely adopted within the U.S. This influenced the research since part of the privatization effort in family housing was to meet national standards but not exceed them. It was apparent the U.S. Marine Corps exceeded the requirements of the private housing market by requiring the range hood fire protection systems for it's family housing.

Range Hood Fire Extinguishing System Costs

The U.S. Department of the Air Force (1993) policy review estimated the installed cost of the range hood fire extinguishing systems at $357.50 per unit and the annual service cost at $40 per system per year. The major service cost, conducted at 12-year intervals, was estimated at $150.00 per system. The U.S. Air Force estimated they had 124,000 units without range hood fire extinguishing systems, therefore the cost to install systems in all their housing was estimated at over $44 million dollars and the annual maintenance cost was estimated at almost $5 million per year. The U.S. Air Force estimated savings of $528,000 per year from direct property loss and $25,000 per year in injury reduction if the range hood systems were installed in all housing. As a result, the benefit to cost ratio for the range hood fire extinguishing systems was calculated at 0.05 with a payback period exceeding 200 years. The status quo alternative with no protection had a benefit to cost ratio of 1.00. Since the alternative with the largest benefit to cost ratio was considered the more cost-effective alternative, status quo was identified as a much better alternative. As a result of this analysis, the U.S. Air Force eliminated the requirement for range hood fire extinguishing systems in their family housing construction projects.

The only other cost information obtained during the literature review was the price lists for range hood fire extinguishing equipment obtained from the 1997 General Service Administration Authorized Federal Supply Schedule. The Guardian system, manufactured by Twenty First Century Fire Equipment, lists for $315.00 (electric range) and $335.00 (gas range). These prices include an electric or gas fuel shut-off. PEM-ALL manufacturers the Safety Gourmet system which lists for $349.36 (electric range) and $355.15 (gas range). These prices also include the appropriate fuel shutoff. Installation is estimated at $80 to $100 dollars for each system so the total cost is approximately $395 to $455 per system.

J.P. Rouse (personal communication, February 6, 1998) stated the range hood fire extinguishing system manufactured by Twenty First Century International only requires an annual visual inspection of the system as long as reusable detection links were utilized. He estimated this only takes 15 to 20 minutes per system, so the annual service costs were minimal.

Chief M.P. Soderberg (personal communication, January 5, 1998) indicated the U.S. Marine Corps Base, Camp Pendleton Fire Department does annual inspections of the range hood fire extinguishing systems. He estimated it only takes five to ten minutes to visually inspect the system in each house and the cost of the inspection is relatively minor.

The literature review did not yield much information on the range hood fire extinguishing system costs other than the system equipment and service costs. With the exception of the U.S. Department of the Air Force (1993) policy review, there was no information on the cost benefit of installing the range hood fire extinguishing systems. The U.S. Air Force study influenced this research by suggesting that no protection was significantly more cost beneficial than installing the range hood fire extinguishing systems.

Range Hood Fire Extinguishing System Performance

Chiefs' C.M. Moore (personal communication, January 5, 1998), M.P. Soderberg (personal communication, January 5, 1998) and C.E. Methvin (personal communication, February 5, 1998) indicated the range hood fire extinguishing systems had performed well on range fires in U.S. Marine Corps family housing. Chief Moore stated the range hood systems had substantially reduced the fire losses in family housing at U.S. Marine Corps Air Station, Cherry Point because most fires were range fires.

No information was found during the literature review on the performance of range hood fire extinguishing systems outside of the military services. It is not clear if this is due to the limited application of these systems or the lack of any analysis on the range hood fire extinguishing system performance.

Tremblay (1997a, 1997b, 1996, 1993a, 1993b, 1993c) reported on six incidents where residential sprinklers successfully extinguished cooking fires in residential occupancies. All but one of the fires involved unattended cooking and a single residential sprinkler head successfully extinguished all the fires. There were no fatalities, three minor injuries and damages ranged from $500 to $5000 in the fires.

The performance of the range hood fire extinguishing systems and residential sprinkler systems influenced this research by indicating either system will control and extinguish cooking fires. The chief in charge of one fire investigation reported by NFPA stated " Once again, lives were saved and property damage was minimal because of residential sprinklers" (Tremblay, 1993a, p. 27).

Procedures

Procedures used in this research began with a literature review at the Learning Resource Center at the National Emergency Training Center in September 1997. Additional literature reviews were conducted with the NFPA Fire Analysis and Research Division and the Headquarters U.S. Marine Corps Fire Protection Programs library and files. The literature reviews took place between September 1997 and January 1998.

The literature review focused on four major areas. The first was a search for sources that addressed the magnitude of the family housing cooking fire problem in the U.S. and specifically within the military services. The second search attempted to identify any codes and standards that mandated the installation of range hood fire extinguishing systems in family housing. The third search was for sources that identified the costs associated with range hood fire protection systems. This search intended to identify the cost of installing, maintaining and servicing the range hood fire protection systems as well as the cost avoidance (reduced fire losses, injuries and fatalities) of the installed systems. The last search attempted to identify previous performance indicators of the range hood fire extinguishing systems as well as the performance of residential sprinkler systems on range cooking fires.

Telephone interviews were conducted with Stephen A. Scully, Military Family Housing Branch Chief at the National Association of Home Builders National Research Center on January 2, 1998 and with J. Paul Rouse, Managing Director, Twenty First Century International Fire Equipment and Services Corporation on February 6, 1998. Mr. Scully and Mr. Rouse were interviewed to develop information on the costs associated with range hood fire extinguishing systems and to offer their assessment on the need for such systems in family housing.

Fire Chief Cecil M. Moore of the U.S. Marine Corps Air Station, Cherry Point Fire Department and Assistant Fire Chief Mark P. Soderberg of the U.S. Marine Corps Base, Camp Pendleton Fire Department were interviewed by telephone on January 5, 1998. Fire Chief Charles E. Methvin of the U.S. Marine Corps Air Ground Combat Center,

Twentynine Palms Fire Department was interviewed by telephone on February 5, 1998. Chiefs' Moore, Soderberg and Methvin were interviewed to gain an U.S. Marine Corps perspective on the costs, inspection procedures and performance of the range hood fire extinguishing systems.

Russell Miller of the Naval Safety Center was interviewed by telephone on February 4, 1998 concerning the fire loss data provided from the Naval Safety Center database.

Fire loss data was requested from the Naval Safety Center on family housing and stove fires within the U.S. Marine Corps. The Naval Safety Center is the central repository for all fire loss data reported by the U.S. Department of Defense fire departments and thus maintains the data for the U.S. Marine Corps. The data requested included the fire loss breakout (number of responses, injuries, fatalities and Government property loss) for family housing fires where the area of fire origin was the kitchen and the equipment involved was a stove. Data was requested for FY1987 through FY1997. For comparison purposes, data was also requested on the fire loss breakout for all U.S. Marine Corps family housing and total fire losses in the same time period. Data requested included stove fire ignition factors, residential sprinkler performance and range hood fire extinguishing system performance. The purpose of the fire loss data was to determine the extent and magnitude of the cooking fire problem within the U.S. Marine Corps. The data was also requested to determine the performance of residential sprinklers and range hood fire extinguishing systems on the stove fires.

After receipt of the data from the Naval Safety Center, it was apparent the data was incomplete. This was verified by comparing the annual fire loss summary reports from the Naval Safety Center with the specific data requested from the Naval Safety Center database. Complete summary reports on the U.S. Marine Corps fire losses were obtained from the Headquarters U.S. Marine Corps Fire Protection Programs files for FY1991 through FY1995. The annual summary reports include specific fire loss tables to provide an overview of the fire problems and trends in each military service. According to R. Miller (personal communication, February 4, 1998), who monitors the data at the Naval Safety Center, some of the data from the Naval Safety Center database was most likely lost during the transfer to a new computer system in 1996. As a result, only the data from the summary reports was utilized in the analysis. Appendix A contains excerpts from summary reports showing the U.S. Marine Corps fire loss breakouts for total fire loss, family housing fire loss, kitchen fire loss and stove fire loss.

Individual fire loss reports were examined for stove fires where range hood fire extinguishing systems or residential sprinkler systems operated from FY1991 through FY1995. Fire investigation reports for all U.S. Marine Corps fire deaths in family housing were examined from 1979 through 1997 to determine the life loss associated with stove cooking fires. The fire loss reports and fire investigation reports were obtained from the Headquarters U.S. Marine Corps Fire Protection Programs files.

The data from summary reports, fire loss reports and fire investigation reports was analyzed to make an assessment of the cooking fire problem in U.S. Marine Corps family housing. The data was also evaluated to determine the loss reduction associated with the installation of the range hood fire extinguishing systems and residential sprinkler systems.

The final procedure for this research was a net present cost analysis evaluating three different levels of protection for stove fires in U.S. Marine Corps family housing. The first analysis evaluated no protection except for the smoke detectors that were installed in all family housing. This analysis utilized the average fire loss for stove fires from the summary reports as the annual cost factor. The second analysis evaluated the range hood fire extinguishing systems. This analysis evaluated the purchase, installation and major service costs of the range hood fire extinguishing systems as well as the average fire loss from stove fires where range hood systems operated. The last analysis evaluated the average fire loss from stove fires where residential sprinklers operated. All costs were escalated to fiscal year 1997, which was considered the base year for the analysis.

The net present cost analysis was used to assess the cost of the range hood fire extinguishing systems and to determine if the range hood fire extinguishing systems provided cost effective protection against stove fires.

Limitations and Assumptions

A major limitation of this research was the incomplete data provided from the Naval Safety Center database. As a result, the data analysis was limited to the information provided in the annual fire loss summary reports. It was not possible to isolate or compare various data elements that may have provided a clearer picture of the cooking fire problem in the U.S. Marine Corps. As an example, it was the intent of this research to evaluate the type and extent of fire injuries received from stove fires. However, because these data elements were not isolated in the summary report tables, this evaluation was not possible. The research was limited to the number of injuries from kitchen fires since these two data elements are included in a summary table.

The small number of incidents that involved the operation of range hood fire extinguishing systems or residential sprinkler systems also limited the research. There were only eight reported incidents involving the range hood fire extinguishing systems on stove fires and just three incidents involving residential sprinklers. With such a small sample, it was not possible to establish a high level of confidence in the data from these incidents.

The fire loss data provided to the Naval Safety Center was taken from fire reports submitted by the U.S. Department of Defense fire departments. As a result, the data was limited to the fire department's assessment of the fire cause and fire loss. Since much of this information was subjective, this was another limitation of this research.

There were a number of assumptions used in the net present cost analysis as follows:

1. The service life of the range hood fire extinguishing and residential sprinkler systems was assumed at 25 years. This corresponds to the expected service life of a fully renovated family housing unit.

2. The purchase and installation cost of the range hood fire extinguishing systems was $400 per system.

3. A major service of the range hood fire extinguishing systems takes place on the 12th year of service and costs $150 per system. This service includes a hydrostatic test of the extinguishing system cylinder and hose assembly. No major service takes place at the 24th year since there was only one year of useful service life remaining.

4. No routine maintenance or service costs were included for either the range hood fire extinguishing or residential sprinkler systems. The costs were assumed to be negligible and covered under existing family housing maintenance programs.

5. The purchase and installation cost of the residential sprinkler systems was considered a sunk cost for protection of the stoves since it was already required by U.S. Marine Corps policy. For comparison purposes, the cost was assumed at $1,500 per housing unit.

6 There were 25,123 family housing units within the U.S. Marine Corps inventory as of FY1997 (Commandant of the Marine Corps, 1998). Within the inventory, 3751 units already have range hood fire extinguishing systems and 3828 units have residential sprinkler systems.

7. A five-percent interest rate was assumed in calculating the net present costs.

8. Escalation of fire losses was based on the U.S. Department of the Navy Price Escalation Indices for Base Fiscal Year 1997.

Definitions

For the purposes of this research, the following definitions apply:

Fiscal Year (FY): The time period from October 1 through September 30 of the following year as established by the U.S. Department of Defense for budgeting and programming purposes.

Family Housing: Buildings containing one, two or multiple living units for military personnel and their dependents with independent cooking, living, sleeping and bathroom facilities.

Range: A cooking unit consisting of a stove and oven combined in one unit. For the purposes of this research, ranges and stoves are considered synonymous.

Range Hood Fire Extinguishing System: An extinguishing system capable of automatically detecting, suppressing and preventing re-ignition of stove fires with a range hood. The system consists of a refillable cylinder with wet or dry chemical extinguishing agent, a reusable automatic detection system, fuel/power shutoff and an automatic release of the extinguishing agent.

Residential Sprinkler System: An automatic, fast response sprinkler system designed for protection of fire hazards typically found in family housing.

Stove: The principal fixed, stationary, surface-cooking unit installed in family housing kitchens.

Results

1. What is the fire loss history from range fires in U.S. Marine Corps family housing?

Table 2 provides a breakout on the number of fires, injuries and government property loss associated with stove fires in U.S. Marine Corps family housing. The data indicates the U.S. Marine Corps averaged 34 stove fires a year in family housing that resulted in an average of four injuries per year and $55,988 in property loss. The stove fires accounted for a substantial portion of the family housing responses (47%) and the family housing injuries (62%) but only accounted for 20% of the family housing property loss. When compared with the total U.S. Marine Corps fire loss breakout, stove fires accounted for 14% of the responses, 14% of the injuries and less than one percent of the total government property loss. See Appendix A for complete data on the U.S. Marine Corps fire losses.

With approximately 25,000 family housing units in the U.S. Marine Corps inventory, the stove fire rate was approximately 0.14 percent per housing unit per year and the injury rate was approximately 0.02 percent per housing unit per year. These rates are very consistent with the rates of 0.11 percent and 0.02 percent observed in the 1993 U.S. Air Force policy review.

Table 3 provides a breakout of the U.S. Marine Corps family housing fire fatalities from 1979 through 1997. The data indicates there have been eight fatalities in 19 years with one attributed to a stove fire.

Table 2

FY1991 – FY1995 U.S. Marine Corps Family Housing Stove Fires

FY	Stove fires	Injuries	Property loss (then year)	Property loss (escalated to FY1997)
1991	42	4	$39,591	$44,484
1992	33	4	$43,389	$47,719
1993	34	3	$66,042	$71,193
1994	30	4	$78,107	$82,778
1995	29	3	$32,337	$33,766
Total	168	18	$259,337	$279,940
Average	34	4	$51,867	$55,988

Note: Injuries not available for fire loss with stove as equipment involved in ignition. Table assumes all kitchen fire loss injuries are due to stove fires.

Table 3

FY1979 - FY1997 U.S. Marine Corps Family Housing Fire Fatalities

FY	Fatalities	Cause	Location of origin
1982	1	Accidental	Living Room
1983	1	Suicide	Bedroom
1984	1	Juvenile Fire Setter	Bedroom
1984	1	Undetermined	Bedroom Closet
1985	1	Juvenile Fire Setter	Living Room
1994	2	Murder/Suicide	Kitchen
1995	1	Unattended Cooking	Kitchen Stove
Total	8		

2. Does the literature support the installation of range hood fire extinguishing systems in family housing?

The literature review did not document any requirements for range hood fire extinguishing systems except in the military services. None of the major U.S. building or life safety codes required the systems in family housing. Hall (1997) also did not recommend range hood fire extinguishing systems in the NFPA report on U.S. Home Cooking Fire Patterns and Trends. Within the military services, Military Handbook 1008C (1997) only requires range hood fire extinguishing systems for common cooking areas in personnel housing facilities such as barracks and dormitories. There is no requirement for range hood fire extinguishing systems in family housing units.

The U.S. Air Force previously required range hood fire extinguishing systems for high rise family housing based on the unacceptable risk of a high rise fire. However, after conducting the life cycle cost analysis on kitchen range protection, the U.S. Air Force revised their policy and deleted the requirement for the systems (U.S. Department of the Air Force, 1993).

Based on the literature review conducted for this research, the U.S. Marine Corps remains the only military service that mandates the range hood fire extinguishing systems in family housing.

3. What is the cost of range hood fire extinguishing systems?

The net present cost analysis of the range hood fire extinguishing system alternative produced a cost of $10,409,023. This cost was based on an initial installation cost of $8,548,000, annual fire losses of $5,338 from 34 stove fires and a major service cost of $3,205,800 in the 12th year. In comparison, the no protection alternative produced a cost of $785,095. This was based on an annual loss of $55,988 for the 34 stove fires per year. See Appendix B for the net present cost calculations.

4. Does the installation of residential sprinklers have an affect on the need for range hood fire extinguishing systems in family housing?

Table 4 provides data on the operation of residential sprinkler systems on stove fires in U.S. Marine Corps family housing. The data from the three incidents indicates the average property loss was $271 per stove fire with no injuries or fatalities. In all three cases, a range hood fire extinguishing system protected the stove. The range hood system did not operate because the safety control pin was not removed in two cases and the systems contained an improper high temperature activation link in the third case.

The net present cost analysis of the residential sprinkler alternative produced a cost of $129,862. This was based on an average loss of $271 per fire for the 34 stove fires per year or $9,214 fire loss per year. Installation costs were not included since they were considered sunk costs. For comparative purposes, including the residential sprinkler installation costs adds $31,942,500 based on $1,500 per housing unit.

Table 5 provides data on the operation of the range hood fire extinguishing systems on stove fires in U.S. Marine Corps family housing. The data from the eight incidents indicates the average property loss was $157 per stove fire with one injury and no fatalities.

The data from Tables 4 and 5 indicated the property losses from stove fires increased by slightly more than $100 when extinguished by a range hood fire extinguishing system as opposed to a residential sprinkler system. See Appendix B for the net present cost calculations.

Table 4

FY1991 – FY1995 U.S. Marine Corps Residential Sprinkler Operations On Family Housing Stove Fires

Date	Injuries	Fatalities	Property loss (then year)	Property loss (escalated to FY1997)
1-4-95	0	0	$200	$209
3-26-94	0	0	$50	$53
1-8-92	0	0	$500	$550
Total	0	0	$750	$812
Average	0	0	$250	$271

Table 5

FY1991 - FY1995 U.S. Marine Corps Range Hood Fire Extinguishing System Operations On Family Housing Stove Fires

Date	Injuries	Fatalities	Property loss (then year)	Property loss (escalated to FY1997)
10-21-95	0	0	$179	$187
10-1-95	0	0	$320	$334
5-5-95	0	0	$333	$347
1-22-95	0	0	$191	$199
9-6-93	0	0	$42	$45
7-4-93	0	0	$0	$0
7-7-93	0	0	$80	$86
2-20-92	1	0	$50	$55
Total	1	0	$1195	$1253
Average	0	0	$149	$157

Discussion

The results of the research indicated that stove fires were significant when compared with all family housing fires in the U.S. Marine Corps. The stove fires were responsible for a large number of fires (47 percent) and a majority of fire injuries (62 percent) within family housing. This data was consistent with McGill et al. (1988) which found that 45 percent of all family housing fires in the U.S. Air Force occur as a result of cooking. The findings were also consistent with Hall (1997) which indicated stove fires were the major causes of fires and injuries in home fires reported to U.S. fire departments. The stove fire rate (0.14 percent) and injury rate (0.02 percent) was very consistent with that observed in the 1993 U.S. Department of the Air Force policy review.

The U.S. Marine Corps property loss from stove fires in family housing was significantly less than that observed in the U.S. Department of the Air Force (1993) policy review and by Hall (1997). At $1,525 per fire in property loss (then year dollars), the U.S. Marine Corps fire loss is less than half the loss observed in the other two studies.

The fire loss data indicated that stove fires are much less significant when compared with all U.S. Marine Corps fires. Stove fires accounted for only 14 percent of the fire responses, 14 percent of the fire injuries and less than one percent of fire property loss. The data also indicated the incidence of stove fires has decreased significantly since 1988 when the U.S. Marine Corps was averaging 100 stove fires per year (Commandant of the Marine Corps, 1988).

The data suggests it was very rare for person to die as result of a stove fire in U.S. Marine Corps family housing. In 19 years, there has only been one fire fatality attributed to a fire starting on a stove. This is consistent with the U.S. Department of the Air Force (1993) which reported no fire deaths due to kitchen fires from FY1984 through FY1991. It is evident that part of the reason for the very low fatality rate was the overall outstanding fire death record in U.S. Marine Corps family housing. Since 1979, there have only been eight fire fatalities in U.S. Marine Corps family housing with the majority caused by juvenile fire setters or suicides.

The fire loss data from the U.S. Marine Corps indicated stove fires should not be ignored because they still were responsible for a significant number of fires and injuries in U.S. Marine Corps family housing. However, the data also indicated stove fires were not a major problem in the U.S. Marine Corps. Stove fires generally cause few

injuries, almost no fire deaths and very small property losses compared to other types of fires. The data also indicated the stove fire problem was decreasing in magnitude with fewer responses and less property damage than previously observed.

The research clearly showed the U.S. Marine Corps was the only military service mandating range hood fire extinguishing systems. There also was no apparent effort by any of the major U.S. building or life safety codes to mandate this type of protection. With the military services pushing for privatization of family housing, the U.S. Marine Corps will not be able to justify installing the range hood fire extinguishing systems on the basis of a national code or standard.

The net present cost analysis indicated the no protection alternative was substantially less expensive than installing the range hood fire extinguishing systems. The range hood fire extinguishing system alternative would cost the U.S. Marine Corps approximately $9,624,000 more than the no protection alternative over the 25 year service life. The major expense was the installation cost of the range hood fire extinguishing systems for 21,372 housing units. The fire loss savings of $50,650 from 34 stove fires a year cannot overcome the $8,548,000 installation cost.

The results of the U.S. Marine Corps net present cost analysis were consistent with that reported by the U.S. Department of the Air Force (1993). The U.S. Air Force analysis also found the no protection alternative substantially less expensive than the range hood fire extinguishing system alternative.

A review of the range hood fire extinguishing system and residential sprinkler system performance indicated both perform very well on stove fires. The average property loss from a stove fire extinguished by a range hood fire extinguishing system is less than $150 (then year dollars). Surprisingly, the average loss from a stove fire extinguished by a residential sprinkler system was only $250 (then year dollars) or just over one hundred dollars more than the range hood system. The residential sprinkler loss is somewhat lower than that reported by Tremblay (1997a,1997b,1993a,1993b,1993c) of $500 to $5000 per incident.

The net present cost analysis indicated the residential sprinkler alternative was the best alternative. The cost of the residential sprinkler alternative was approximately $655,000 less than the no protection alternative and more than $10,000,000 less than the range hood fire extinguishing system alternative. The analysis did not include the cost of the residential sprinklers because the sprinklers were already required for multifamily housing and they provide protection for more than just the stove. The analysis clearly indicated residential sprinklers were the most

expensive alternative if they were installed just for stove fires. It would cost approximately $32,000,000 to install residential sprinklers in the 21,295 family housing units without sprinkler protection. However, one of the major advantages of residential sprinklers was that they provide protection for all the living spaces in family housing. This was part of the justification used by the U.S. Marine Corps to keep the sprinklers in multifamily housing.

The net present cost analysis does not support the installation of the range hood fire extinguishing systems in U.S. Marine Corps family housing. Both the no protection and residential sprinkler alternatives were significantly less expensive. With the emphasis on cost reduction for the privatization initiatives, the U.S. Marine Corps can not justify the range hood systems on a cost basis.

Recommendations

The most important recommendation stemming from this research was that the U.S. Marine Corps should discontinue its policy of installing range hood fire extinguishing systems in family housing construction projects. The excellent fire loss record in U.S. Marine Corps family housing, the high cost to install range hood fire extinguishing systems in all family housing and the lack of a national code or standard mandating the requirements does not support the need for the systems. The fire risk reduction gained by the range hood fire extinguishing systems does not justify the expense of installing and maintaining the systems.

The research indicated that residential sprinklers do successfully extinguish and control stove fires and will provide a high level of protection for stove fires. The installation of the residential sprinklers provides a significant risk reduction from stove fires and further eliminates the need for the range hood fire extinguishing systems.

As a result of the above recommendation, the U.S. Marine Corps Order on Family Housing Management (Commandant of the Marine Corps, 1990) should be revised to eliminate the requirement for range hood fire extinguishing systems in U.S. Marine Corps family housing construction.

Because stove fires remain a concern in U.S. Marine Corps family housing, U.S. Marine Corps fire departments should continue and expand their public fire education efforts on stove fires. The public fire education programs should focus on supervision of cooking, using cooking equipment properly, avoiding late night cooking

and avoiding loose fitting clothing when cooking. These recommendations are consistent with the recommendations by Hall (1997).

It is imperative that the Naval Safety Center addresses the problems with the U.S. Department of Defense fire loss database. The incomplete data hindered this research and will substantially affect the analysis of all U.S. Department of Defense fire programs if the database can not be updated.

Regular monitoring of cooking and stove fires is recommended to ensure the losses remain under control. The use of range hood fire extinguishing systems should be revisited if stove fire losses increase substantially. This is especially important for one and two family housing since residential sprinklers will no longer be installed in this type of housing.

Finally, additional research is recommended for the residential sprinkler performance on stove fires. While the data observed in this research was very positive, it was a very small sample. Therefore, it will be important to continue validating the residential sprinkler performance in the future.

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Appendix A

U.S. Marine Corps Fire Losses for FY1991 – FY1995

Table A-1

Total U.S. Marine Corps Fire Loss:

FY	Fire loss responses	Injuries	Deaths	Property loss (then year)	Property loss (escalated to FY1997)
1991	286	23	0	$29,147,190	$32,749,782
1992	299	28	0	$11,906,955	$13,095,269
1993	240	14	0	$623,503	$672,136
1994	187	34	2	$27,136,539	$28,754,304
1995	216	27	1	$1,612,818	$1,684,105
Total	1228	126	3	$70,427,005	$76,960,596

Table A-2

Total U.S. Marine Corps Family Housing Fire Loss:

FY	Fire loss responses	Injuries	Deaths	Property loss (then year)	Property loss (escalated to FY1997)
1991	73	4	0	$72,273	$81,206
1992	74	7	0	$338,659	$372,457
1993	80	6	0	$272,112	$293,336
1994	63	5	2	$269,181	$285,278
1995	66	7	1	$273,354	$285,436
Total	356	29	3	$1,225,579	$1,317,713

Table A-3

Total U.S. Marine Corps Family Housing Fire Loss With Kitchen As Area Of Fire Origin:

FY	Fire loss responses	Injuries	Deaths	Property loss (then year)	Property loss (escalated to FY1997)
1991	55	4	0	$43,946	$49,378
1992	38	4	0	$44,419	$48,852
1993	43	3	0	$69,102	$74,492
1994	39	4	2	$102,474	$108,602
1995	34	3	1	$48,301	$50,436
Total	209	18	3	$308,242	$331,760

Table A-4

Total U.S. Marine Corps Family Housing Fire Loss With Stove As Equipment Involved In Ignition:

FY	Fire loss responses	Injuries	Deaths	Property loss (then year)	Property loss (escalated to FY1997)
1991	42	4	0	$39,591	$44,484
1992	33	7	0	$43,389	$47,719
1993	34	6	0	$66,042	$71,193
1994	30	5	0	$78,107	$82,778
1995	29	7	1	$32,337	$33,766
Total	168	29	1	$259,466	$279,940

Note: Injuries not available for fire loss with stove as equipment involved in ignition. Table assumes all kitchen fire loss injuries are due to stove fires.

Appendix B

Net Present Cost Analysis of Range Fire Protection Alternatives

1. No Protection Alternative Analysis.

A = Annual Fire Loss from Stove Fires (FY 1997): $279,940/5 = $55,988

n = 25 Year Analysis Time Frame

i = Interest Rate of 5 Percent

P = Net Present Cost

(P/A,i,n) = Series Present Worth Factor (Newnan, 1977)

P = A(P/A,i,n) = $55,988(14.094) = $789,095

2. Range Hood Fire Extinguishing System Alternative Analysis

P(i) = Initial Purchase and Installation Cost of Range Hood Fire Extinguishing Systems:

21,372 Units x $400/Unit = $8,548,800

A =. Annual Fire Loss from Stove Fires Protected with Range Hood Fire Extinguishing Systems (FY 1997): $157 x 34

Stove Fires = $5,338

F = Major Service Cost at 12 years: 21,372 units x $150/unit = $3,205,800

n = 25 Year Analysis Time Frame

N = 12 Year Major Service Time Frame

i = Interest Rate of 5 Percent

P = Net Present Cost

(P/A,i,n) = Series Present Worth Factor (Newnan, 1977)

(P/F,i,N) = Present Worth Factor (Newnan, 1977)

P = P(i) + A(P/A,i,n) + F(P/F,i,N)

P = $8,548,800 + $5,338(14.094) +$3,205,800(0.5568) = $10,409,023

3. Residential Sprinkler System Alternative Analysis

P(i) = Initial Purchase and Installation Cost of Residential Sprinkler System: $0 (Sunk Cost)

A = Annual Fire Loss from Stove Fires Protected by Residential Sprinkler System (FY1997):

$271 x 34 Stove Fires = $9,214

n = 25 Year Analysis Time Frame

i = Interest Rate of 5 Percent

P = Net Present Cost

(P/A,i,n) = Series Present Worth Factor (Newnan, 1977)

P = P(i) + A(P/A,i,n)

P = $0 + $9,214(14.094) = $129,862

If P(i) Includes Initial Purchase and Installation Cost of Residential Sprinkler System:

21,295 Units x $1,500/Unit = $31,942,500

P = P(i) + A(P/A,i,n)

P = $31,942,500 + $9,214(14.094) = $32,072,362