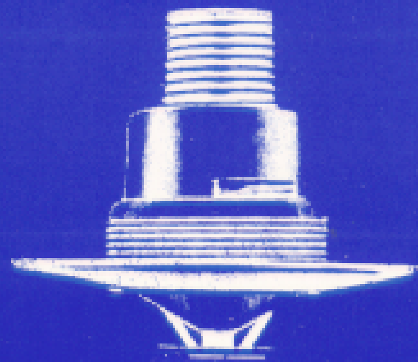
RESIDENTIAL FIRE SPRINKLERS RETROFIT DEMONSTRATION PROJECT



Final Report

Phase II: Single-Family Structures

FEDERAL EMERGENCY MANAGEMENT AGENCY

UNITED STATES FIRE ADMINISTRATION

- 96 / September 1990

NOTICE

FINAL REPORT

RESIDENTIAL FIRE SPRINKLERS RETROFIT DEMONSTRATION PROJECT

Phase II: Single Family Structures

Cooperative Agreement No. HA-12963

Submitted to:

U.S. Fire Administration
Emmitsburg, MD 21727

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TABLE OF CONTENTS

INTRODUCTION

The goal of the U.S. Fire Administration (USFA) is to reduce the number of fire deaths and injuries occurring annually in the United States. They recognize, and statistics show, that certain populations face disproportionately high risk of death and injury due to fire. Those "high risk" groups include children, the elderly, persons with disabilities, and low income households. Furthermore, most residential fire fatalities in the U.S. occur in older structures rather than new homes. The U.S. Department of Housing and Urban Development (HUD) has a common interest in the older housing stock, particularly the thousands of low income units that undergo rehabilitation with HUD subsidies. The USFA and HUD believe that by retrofitting fire suppression systems in existing high risk dwellings, significant reductions can be made in the loss of life and property.

In September 1989, the USFA released a report entitled *'Residential Fire Sprinklers Retrofit Demonstration Project - Phase I: Multifamily Structures."* That document reported findings from a cooperative technical assistance project between the USFA, HUD, and the NAHB National Research Center (Research Center). The primary objective of the project was to investigate the technical and regulatory barriers to including residential fire sprinklers in HUD-funded multifamily rehabilitation projects. Phase I successfully installed fire sprinkler systems in 51 occupied units. As reported in the Phase I *Final Report,* a second Phase was in progress which focused on single-family units in other jurisdictions around the U.S.

This *Final Report* represents a summary of the information gathered and lessons learned by the Research Center during Phase II of the project. It includes both qualitative and quantitative information, as well as closing recommendations. Some information from Phase I has been repeated so comparisons could be made between single- and multifamily buildings. In addition, the Research Center has compiled site-specific information into *Case Studies* for each of the participating communities. The *Case Studies* are the companion document to this report and detail on a site-by-site basis the project history, community characteristics, sprinkler system design, installation, and costs, as well as local Outreach efforts. Copies of the Phase I and Phase II *Case Studies* as well as the Phase *I Final Report* are available from the USFA as separate publications. *Fact Sheets* for each of the sites are included at the end of this report. They provide names and phone numbers of key persons, building photographs, and other site-specific information for each of the participating communities.

BACKGROUND

Communities participating in Phase II of the project were: the **City and County of Denver, Colorado;** the **City of Seattle, Washington;** the **State of Florida;** and the **State of Ohio.** Installations were successfully accomplished in three of these jurisdictions. Ten structures comprising a total of 19 households were retrofitted with NFPA-13D systems; nine of the structures were single-family detached homes. The Seattle building was a large Victorian house which had been converted to a IO-unit apartment house. All the buildings were undergoing rehabilitation when the systems were installed, and all except the apartment house were owner-occupied. Each of the structures engaged for the project was rehabilitated with financial assistance from HUD, provided through the local community development agency. In addition, the participating sites received separate grants from USFA for funding of the actual fire sprinkler system installation. The USFA grants were comprised of two parts: monies for the actual sprinkler system installation; and, a smaller part earmarked for a local public education, or *Outreach* effort. The type of *Outreach* program done at each site was largely at the discretion of the local grantee, and included such things as fire sprinkler brochures, workshops and training sessions, slide shows, videos, and local media events.

To make a logical comparison of single- and multifamily buildings, some Phase I and Phase II data is intermingled in the tables and charts that follow. That is, though Austin was a Phase I site, the buildings selected there were actually single-family attached units (duplexes). Similarly, Seattle was a Phase II site but the building selected was a large Victorian style mansion which had been converted to apartments; thus, it will be classified as a multifamily building. Table 1 is a summary of the class of buildings that participated in Phase I and Phase II of the project. For the bar charts and computed average costs, Austin and Seattle were classified accordingly.

Table I. Classes of Buildings in Phase I and Phase II.

Site	Multifamily	Single-Family
Phase I		
Austin		X
Boston	X	
Harrisburg	X	
Prince Georges County	X	
St. Louis	X	
Phase II		
Denver		X
Florida		X
Seattle	X	
Total Units	**57**	**13**

Three NFPA sprinkler standards were used as reference through the course of the four-year project. They were NFPA-13: *Standard for the Installation of Sprinkler Systems;* **NFPA-13D:**

Standard for Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes; and NFPA-13R: *Standard for Installation of Sprinkler Systems in Residential Occupancies Up To Four Stories in Height.* In general, interpretation and compliance to these standards were at the discretion of the authority having jurisdiction. Installations were done by experienced local fire sprinkler contractors. Permits, plan reviews, and inspections were conducted according to local practice.

The "quick response" sprinkler heads used in all these installations and required by NFPA-13D differ from commercial sprinkler heads in the properties of the fusible element. The time required for the sprinkler head to be exposed to the activation temperature before flow is initiated has been significantly decreased in quick response heads. Also, the physical appearance of the residential heads is designed to be less obtrusive. Figure 1 shows a typical quick response head for residential installations. Most sprinkler head manufacturers now offer quick response heads for residential and light commercial applications. The design premise of NFPA-13D residential fire sprinkler systems utilizing quick response heads is to control incipient fires in the room of fire origin for up to 10 minutes.

Figure 1. Typical Quick Response Pendent Sprinkler Head for Residential Applications. (Courtesy of the Central Sprinkler Company).

The Research Center's primary role in the project was to provide technical assistance to the grantees, facilitate the incorporation of residential fire sprinkler systems (RFS) into the selected buildings, and document all pertinent information for reporting purposes. Local fire and community development departments selected the buildings and contracted with local sprinkler installers. Research Center staff provided on-site assistance to these activities on an as-needed basis. Typically, the Research Center activities included moderating between local government agencies, resolving administrative obstacles, reviewing bids and cost estimates, and generally providing impetus for successful completion of the project. The Research Center also provided administrative support to the sites on all matters regarding the FEMA/USFA grants.

When comparing buildings that are similar, the cost of RFS is best expressed as the cost per-square-foot of included area. “Included area” covers not only areas that are sprinklered, but also areas that were allowed to remain unsprinklered by the local authorities; or, the total area subjected to and approved by the fire department plan review.’ In most residential systems, this includes the total interior space. For example, a bathroom or closet in a sprinklered building would be considered “included area” even though it was not required to be sprinklered. It was on this basis that the “per-square-foot” costs are computed in this report.

[1] In the Phase 1 *Final Report*, we referred to this area as “protected” area. The nomenclature has been changed here for clarity.

SUMMARY OF RESULTS

The variety of characteristics encountered, such as size, construction, existing conditions, and uses of the buildings, provided a broad range of experience and information about retrofitting fire sprinklers in residential buildings undergoing rehabilitation. Useful information was generated regarding the technical and regulatory issues, design criteria, costs, and other practical aspects of retrofit systems. In many cases we found that day-to-day obstacles were administrative in nature, rather than technical or regulatory. Information from these installations may be useful to USFA and HUD when formulating future strategies to address the fire problem in existing residential structures. The costs of the systems and other key observations from the project are summarized below.

- *Total Installed Costs: Single vs. Multifamily.* The multifamily buildings were sprinklered for an average of $2.23/square foot, while single-family buildings averaged $3.17/square foot. The lowest costs incurred on a square foot basis were single family installations in Orange Park (FLA-l), Quincy (FLA3), and Tampa (FLA-7) at $1.50, $1.42, and $1.50, respectively. Prince George’s County, the second largest building in the project at 16,660 square feet, nearly matched these with an installed cost of $1.51 per square

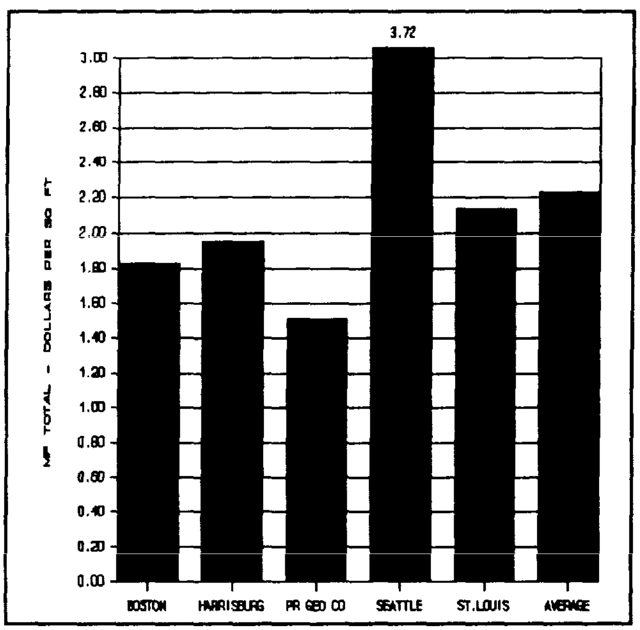

Figure 2. Total Installed Costs for Multifamily Buildings.

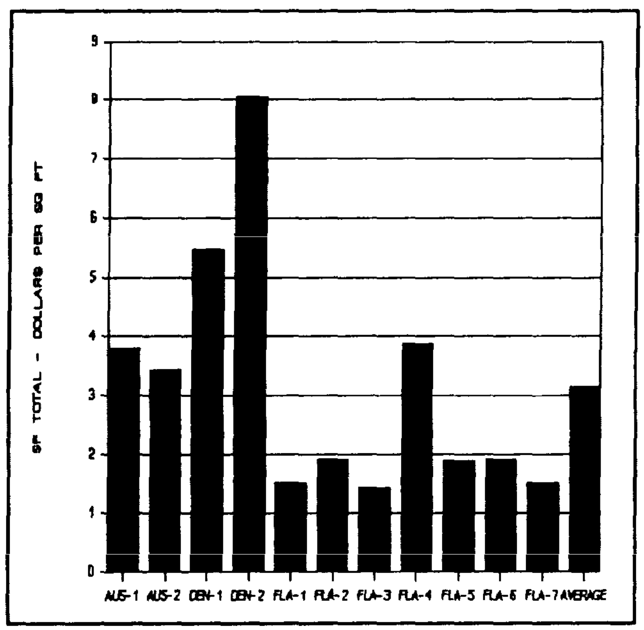

Figure 3. Total Installed Costs for Single Family Buildings.

foot. The fixed costs of sprinkler systems, such as contractor start-up costs, plan reviews, and water hook-ups, have a greater impact on the cost per-square-foot in smaller buildings than in larger buildings. These costs are more easily absorbed in the costs of sprinklering large buildings. Figures 2 and 3 shows the total installed costs per-square-foot for both classes of buildings, and illustrate this economy of scale.

In general, the systems in Florida were the most economical of the single-family buildings - all but one were installed for less than $2/square foot. The cooperation of the Florida Fire Sprinkler Association and the State Fire Marshal's office in all seven installations had a decided influence on the final costs of these systems. Coordination, logistical, and administrative issues were less a problem in Florida than in some other sites where only one or two systems were installed. FLA-4 in rural Jefferson County was a system utilizing a booster pump and storage system and was the only one of its kind in the project. As indicated in Figure 3, its cost was nearly $4/square foot. The Denver systems, installed by a commercial-based contractor, had the highest per-square-foot cost of all sites and clearly drove the average cost for the single-family homes upward. At the time of this reporting, additional work was required at the Denver sites, so the costs were adjusted accordingly based on estimates made by the contractor and Research Center staff for completion of work. We observed that the relatively high fixed costs and low profit margin associated with small buildings served as a disincentive to contractors for such work. In fact, the project team had difficulty securing bids to do the work in Denver.

The Seattle system was particularly expensive at $3.72 per square foot due to the architectural constraints of the building. These costs reflect, in part, the influence floor plan complexity and room size can have on the total cost. Also, because the system piping could not be concealed without major additional expense, copper piping was used throughout for aesthetic and durability reasons. This may have been at least partly responsible for driving this cost upward.

- *Material Costs: Single vs. Multifamily.* Figures 4 and 5 show the material costs for the single- and multifamily buildings as reported by the contractors. Economies of scale are evident here as the multifamily buildings had an average material cost of $0.83 per square foot while single-family buildings incurred an average of $0.92 per square foot. The high material costs associated with Seattle's system are presumably related to the copper pipe system installed there. Otherwise, the material costs per-square-foot for the other four multifamily sites are in close agreement, between 50 and 65 cents per-square-foot.

FLA-4 on Figure 5 was a rural installation without city water that employed a packaged booster pump and storage system. The cost of the package alone was reported as $2,250, which accounted for 50 percent of the total installed cost of the system. Although two fire departments expressed the need for sprinklers in outer rural areas

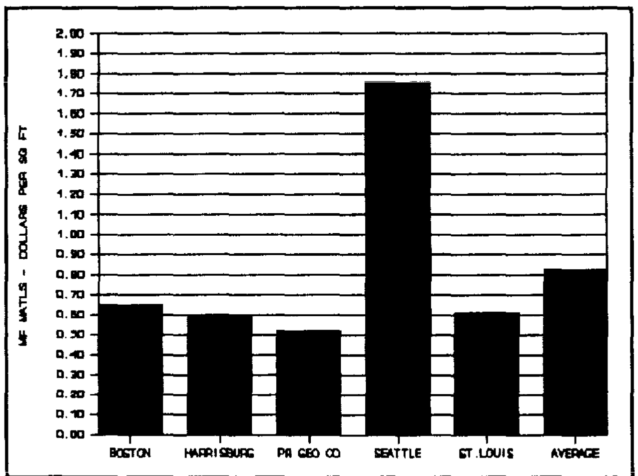

Figure 4. Materials Costs at Multifamily Installations, Dollars Per Square Foot.

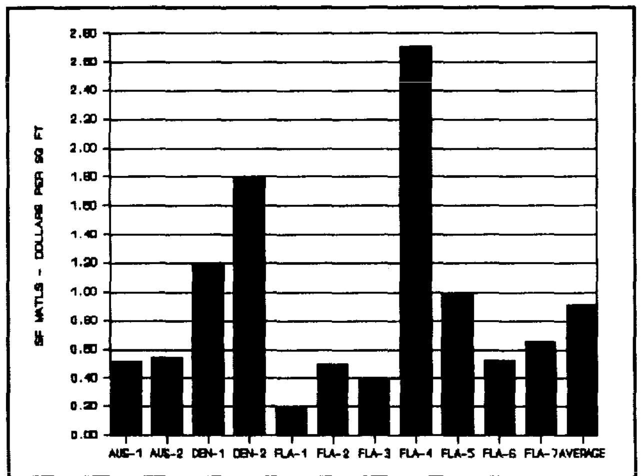

Figure 5. Materials Costs in Single Family Structures, Dollars Per Square Foot.

where engine company response times can be high, these costs suggest that more economical solutions must be sought. At a total installed cost of $4,542 for the booster system, few home owners would be willing or able to make this kind of investment. There was no clear evidence as to why the cost of materials at the two Denver installations was so high.

Labor Costs: Single vs. Multifamily. Costs for labor in the multifamily buildings averaged $1.07 square foot, about 48 percent of the total. Figure 6 shows that labor costs among those five sites varied between $0.84 and $1.36 per-square-foot. These costs are in reasonable agreement considering the diversity in geographic location. As with materials, the costs for labor suggests an economy of scale with the single-family projects reporting labor costs of $1.51 per square foot (Figure 7), 41 percent higher than the multifamily buildings on a square foot basis.

Austin and Florida were in relative agreement on labor costs around $1 per square foot while costs in Denver of $3.41 and $5.07 per square foot were 2 to 3 times the average for single family homes. Again, there was no clear reason why costs in Denver were so high. However, there was difficulty in finding interested bidders for the work, and the Community Development Agency had only two bids from which to select. Labor costs exceeded material costs by 64 percent in all the Phase II single-family homes.

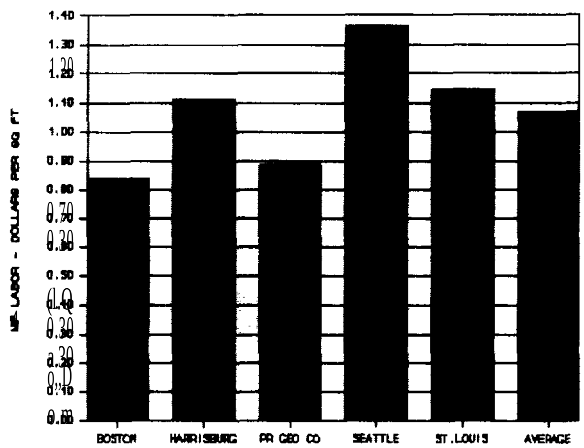

Figure 6. Labor Costs At Multifamily Buildings, Dollars Per Square Foot.

- *Cost Sensitivity.* As reported in Phase I, some installation costs are avoided when systems are installed during “gut” rehabs. Gut rehabs lend themselves to easier installation because of easy access to inner wall cavities. If wall cavities are not exposed, additional work is typically required to protect the piping or make it more aesthetically acceptable. Total cost is also sensitive to the geometry of the protected spaces. Irregularly shaped areas, or “compartments”, tend to require supplemental sprinkler heads to achieve the coverages specified by NFPA standards, thus driving costs upward. This was the case in Seattle, where the floor plan was complex and the existing plaster walls were left in place.

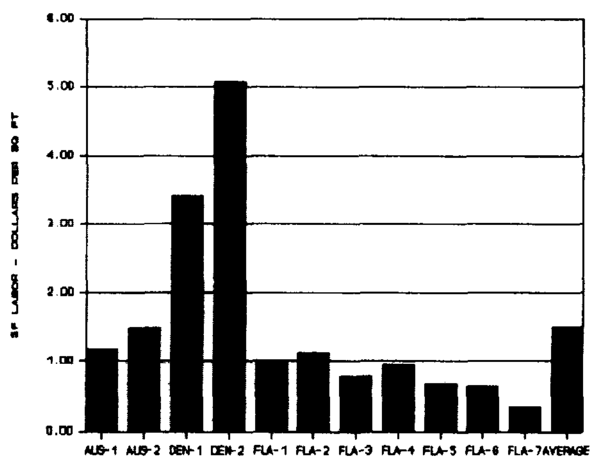

Figure 7. Labor Costs At Single Family Buildings, Dollars Per Square Foot.

In the Phase I Final Report, we reported on the "coverage efficiency" of the installation, i.e., square feet of protected area per sprinkler head. This information is repeated in Table 2, and compared with coverages achieved in single-family dwellings. For a single quick response sprinkler head, NFPA-13D allows a maximum coverage of 144 square feet, unless the head is certified for extended coverage. Some extended coverage heads will sprinkle an area as large as 20' x 20' if adequate pressure is available. The table suggests that 144 SF per head is rarely achieved in actual residential installations.

Table II. Comparisons of Single and Multifamily Coverage Efficiencies.

Site	Total Area Protected (SF)	Total No. of Heads	Coverage Effic. (SF/Head)
Single-Family			
Austin-1	1,280	16	80
Austin-2	1,370	16	86
Denver-1	1,345	13	103
Denver-2	861	9	96
Fla. -1	1,254	11	114
Fla. -2	1,140	10	114
Fla. -3	1,218	10	122
Fla. -4	1,170	11	106
Fla. -5	1,050	11	95
Fla. -6	1,536	14	110
Fla. -7	1,700	14	121
Multifamily			
Boston	21,600	210	103
Harrisburg	7,100	82	87
Prince George's County	16,660	143	117
Seattle	5,320	68	78
St. Louis	8,000	107	75

Additional Water Capacities. Providing new or upgraded water service to meet potential demands of the sprinkler system continued to be an issue in the Phase II buildings. In many of the homes enrolled in rehabilitation programs around the country, including some of those in this project, either the capacity or condition of the water service is antiquated, especially when additional bath and kitchen fixtures are added during the property remodeling. Typical water service size for a single family home is 3/4-inch. Depending on hydraulic conditions at the site, RFS installations may require an increase in total flow capacity or reduction of friction losses. This can be accomplished by adding a new dedicated tap off the city water main, or increasing the size of the existing water service. Again, the economy of these systems in single-family homes is considerably more sensitive to the costs of these upgrades than the larger buildings.

The engineering and construction requirements for this work are ordinary, but the water department fees can be significant. Most "tap fees" vary with the size of the new connection, and the additional connections to city water may or may not be metered, depending on local policy. In Prince George's County, for example, the local water department's current policy is not to charge for water used to fight fires; thus, sprinkler systems can be unmetered. This is beneficial to the engineer too, since the pressure drop through a water meter is typically about 5 psi. The current policy applies to multifamily sprinkler systems, and is expected to extend to single-family homes as well when their single-family ordinance goes into effect in January 1992.

In lieu of metered usage, fixed monthly stand-by fees are sometimes charged for an additional sprinkler service connection. This project was directly responsible for initiating consideration of a new water department policy for residential sprinkler systems in Denver where water use is a sensitive political issue. In this case the water department yielded to pressure from the fire department to waive a substantial tap fee for the sprinkler installations in the two single-family homes there. As of February 1990, the Denver City council is considering a new policy for water charges for residential fire sprinklers, based on the experiences from this pilot project.

When the project commenced, a letter from the Denver water department summarized its policy on residential fire sprinkler systems as follows:

> "... there are two methods of providing fire sprinkler protection to residential structures. The first requires a new fire sprinkler connection to the water main. This connection must be minimum size of 2 inches, will not be metered, and will not require the payment" of tap fees. "A monthly standby charge is assessed for fire line connections," equal to $4.75 for connections under 4 inches in size.
>
> Secondly, a fire sprinkler connection can be made to the service line downstream of the meter. After exiting the meter pit, the service line can be upsized to reduce excessive friction losses without incurring tap fees. If the water main tap, supply line between the tap and the meter, and the meter (which must all be same size) is upsized, the following charges will be assessed:
>
> Increase service from 3/4 to 1 inch - $ 2,730;
> Increase service from 1 to l-1/2 inch - $ 5,460;
> Increase service from l-1/2 to 2 inch - $10,920.
>
> The charge "is based on the amount of potential flow to the structure, and as such is established by the size of the tap. Increasing the domestic tap size, for whatever reason increases potential flow to the structure and hence increases the need for additional raw water, treatment, pumping, storage, and delivery capacity."

As a matter of policy these fees, which do not include the actual construction costs, are not extraordinary; but the exemption for sprinkler systems is based on commercial sprinkler systems requiring a 2-inch service. No exemptions were given to small NFPA-13D systems, and until now none was requested. To summarize, the contractor's first option in this case was to install a dedicated 2-inch fire line to the single-family home with no tap fees. Now, the installation of a 2-inch water service to a single-family home would have been acceptable for this one-time demonstration, but would not be cost-effective as a common practice for future systems. The second option was a l-inch tap downstream of the meter pit with no tap fees. A tap downstream of the meter would not resolve the hydraulic flow and pressure inadequacies at that site. Finally, the third option was to upsize the complete water service from 3/4 to 1 inch at a cost of $2,730 plus construction costs. To ensure adequate pressure head to the sprinkler system, the subcontractor selected the third option, although under ordinary circumstances a $2,730 tap fee would render this or any single-family RFS system uneconomical. Effectively doubling the cost of the system, the fees certainly put the cost of an RFS system out of reach for most home owners. Meanwhile, the fire department was interested in using this opportunity to pursue water department policy changes so as not to discourage future installations of systems of this type. After notification to the water department of the nature and purpose of the project and some negotiations with the fire department, the tap fees (for these two houses only) were reviewed and replaced with a stand-by charge of $l.OO/month to be paid by the home owners, plus construction costs. This was a special arrangement and it was not suggested that this would become permanent policy.

These kinds of circumstances may exist in other jurisdictions. Because the installation of residential sprinkler systems is not a common practice, the procedures and policies are only just evolving to provide these system with the exemptions that are necessary to make them economically viable. However, as this case shows, cooperation among the various local departments is vital to resolving administrative issues.

In St. Petersburg, the water department was unwilling to waive their monthly stand-by fee for an upsized service line. Therefore, rather than burden the home owners with a monthly fee, the project team installed a new dedicated line for the sprinklers which was not subject to fee. In this case, the construction costs to do this were paid by the grant, though such a subsidy would not be available to other home owners considering fire sprinklers. Several other jurisdictions either waived or discounted stand-by fees for the sprinkler systems citing the low likelihood of actual water use.

- *Skill Requirements.* RFS installations can be divided into two basic parts: design and installation. Skill requirements for these are different but often overlap. Skills needed for installation of RFS are within the capability of most professional plumbers; for the most part, materials and techniques are ordinary, and typical of other fluid systems they routinely install.

In general, plumbers do not lack the pipe and fitting know-how to install RFS systems, but rather they lack a working knowledge of the RFS design criteria, such as sprinkler location, spacing, and hydraulic requirements, as specified in the NFPA-13D and 13R standards. Some jurisdictions require specific licensure of fire sprinkler installers, while others do not. The USFA regularly sponsors workshops at many locations around the country which provide training on the various sprinkler standards. These workshops are expected to continue through fiscal year 1990. The actual attendance of licensed plumbers at these workshops was not investigated in the course of this project. Their level of participation in these workshops may be a measure of their awareness of the business opportunities that exist in RFS installations. However, licensing requirements are generally governed by state or local ordinances, and individual inquiries should be made at the local level.

We found that the installation of residential fire sprinkler systems during building rehabilitation is generally not more complicated than installation of standard residential plumbing systems. Complexity can vary according to building size and use, but when incorporated into rehabilitation plans the installation of fire sprinkler systems is unlikely to complicate the overall rehabilitation of the building. Fire officials believe that as more information is available to the general public regarding the relative simplicity of these systems, interest will grow among single-family home owners. We observed considerable unawareness and misunderstanding of RFS among the occupants and homeowners participating in the project. Reluctance to participate was not uncommon, despite the USFA grants to pay for all construction costs. One fire chief related his feeling like a “rug salesman” when soliciting participation in this project among local home owners.

- *Standard and Codes for Residential Systems.* It was during the course of this four year project that NFPA-13R was accepted and published. NFPA-13R addresses the gap that previously existed between NFPA-13 and NFPA-13D; that gap being represented primarily by low-rise multifamily dwellings characteristic of the buildings in Phase I of this project. Prior to that publication, NFPA-13, which was developed for commercial sprinkler systems, was often used by local authorities as the basic criteria. Since 13R did not formally exist during Phase I, some of the completed systems represent a hybrid of NFPA-13 and NFPA-13D. However, the modifications, uses, and interpretations of the standards varied. In some jurisdictions, we observed that there was unfamiliarity and uncertainty in how the sprinkler standards should be applied to the types of rehabs involved in this project.

- *Building Owners’ Criteria.* In the decision-making process leading to installation of sprinkler systems, building owners, especially those that do not reside at the building, generally use economic benefits as the primary criteria. Possible benefits included reduced property insurance costs, higher rents and/or shorter vacancies, flexibility of building code requirements, and reduced probability of uninsured fire losses.

- *Unresolved Issues and Misconceptions.* In the course of the project, some reluctance to be involved with the project was experienced at various levels. Homeowners were wary of system failures and future costs that they would incur, even though initial installation was at no charge to them. Community development and rehab specialists had reservations related to the value of the system in comparison to the frustrations added to the normal rehabilitation process. Local governments expressed uncertainty over incomplete information on several issues. In fact, one of the project sites discontinued participation in the project for reasons explained in the following excerpt from the minutes of a meeting of the local non-profit rehab agency’s board of trustees.

  > “A proposed agreement between the State Fire Marshall’s Office, the Ohio Department of Commerce, and Rehab Project was discussed. If signed, the agreement would make available money to fund a demonstration project where

residential sprinkler systems would be installed. Reservations were expressed on three general levels: 1) There was concern over the burden with excessive water or maintenance fees. It was cited that this could possibly be negotiated with the Utility Department if some payment stipend was made available through the Grant; 2) The excessive cost of the sprinkler system in relation to the overall improvements was cited as inconsistent with our objectives to produce affordable housing; 3) Liability and expense arising from the installation of the system either through failure or malfunction is unknown.

"Recognizing these concerns," a motion was presented to discontinue the pursuit of the project and reject acceptance of the current grant. The motion was seconded and passed.

OTHER PHASE II COSTS

The variety of sizes, types, and conditions of the 5 multifamily and 11 single-family buildings sprinklered during the project created a broad range of information on the cost factors of residential fire sprinkler systems. In Phase I we reported that the decisions of local officials, vendors, and building owners all affected the turnkey costs of RFS in multifamily buildings. In single-family homes, this is generally not the case? The NFPA-13D systems in single-family structures were predictable in terms of required engineering and construction. While there are still unknowns in the smaller jobs, they are fewer in number and not as likely to have significant cost impact. However, these installations show that some unexpected costs can be substantial, usually related to work done outside the boundaries of the house itself.

Regarding the costs reported herein, some comments are in order. In some installations, manufacturers donated materials to the project. The objectives of the project required that the Research Center engineers estimate the retail costs of the donated materials in order to give a true representation of the costs of the sprinkler systems. In the costs reported here, all donated materials have been accounted for and included in their respective categories. Secondly, because the Seattle building was of a different type than the other Phase II structures, it has been separated from the others in these bar charts and not included in the computed averages. For detailed information on the other multifamily buildings not included here, the reader is encouraged to refer to the Phase I *Final Report,* available from USFA.
Table III provides a complete breakdown of the system costs for the Phase II sites. The dollars shown are as reported by the design/installation contractors on cost sheets provided by the Research Center. Material and labor costs were requested for six major categories: Design Fees; Mechanical; Architectural; Electrical; Water Department and Other Fees; and Permits, Plan Reviews and Inspections. The totals given on the table represent the total installed cost that would have been charged to the home owner had the systems not been paid for by the USFA.

Design Costs

At all the Phase II sites, sprinkler system design was performed by local contractors. Generally, sprinkler installation could not begin at any site until after a plan review by the local fire department. Figure 8 shows the dollars charged for design of the system. At about 21 cents

	SEATTLE		DENVER-1		DENVER-2		FLA-1		FLA-2		FLA-3		FLA-4		FLA-5		FLA-6		FLA-7	
	MATL	LABOR	MATL	LABOR	MATL	LABOR	MATL	LABOR	MATL	LABOR	MATL	LABOR	MATL	LABOR	MATL	LABOR	MATL	LABOR	MATL	LABOR
MECHANICAL (Includes pipe, fittings, valves, sprinkler heads, flow switch, etc.)	8,999	5,999	1,610	4,592	1,548	4,368	252	1,230	566	1,279	495	960	3,169	1,114	1,053	496	732	890	909	596
ARCHITECTURAL (Includes drywall repairs framing, carpentry, etc.)	249	994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ELECTRICAL	99	249	0	0	0	0	0	0	0	0	0	0	0	0	0	210	78	84	215	0
MATLS. & LABOR SUBTOTALS	9,347	7,242	1,610	4,592	1,548	4,368	252	1,230	566	1,279	495	960	3,169	1,114	1,053	706	810	974	1,124	596
DESIGN FEES	0	622	0	216	0	216	0	275	0	122	0	275	0	200	0	168	0	496	0	430
WATER DEPT. & OTHER FEES	2,237	0	805	0	678	0	25	0	118	0	0	0	25	34	0	0	500	19	100	250
PERMITS, PLAN REVIEWS & INSPECTIONS	349	0	132	0	132	0	100	0	92	0	0	0	0	0	74	0	79	56	50	0
TOTAL SYSTEM COST		$19,797		$7,355		$6,942		$1,882		$2,177		$1,730		$4,542		$2,001		$2,934		$2,550

DENVER-1: 3145 Gaylord St.; DENVER-2: 3713 Gaylord St.
FLA-1: Miller St., Orange Park; FLA-2: Floyd Circle, Orange Park; FLA-3: Quincy; FLA-4: Jefferson County;
FLA-5: 16th Ave., St. Petersburg; FLA-6: 11th St. South, St. Petersburg; FLA-7: Tampa.

Table III. Summary of All Phase II Costs as Reported by Installers.

per-square-foot, the average design cost for the single-family structures represents a relatively small share of the total. In Seattle, the cost for design of the system was even smaller at less than 12 cents per-square-foot although the design fee was the highest of all these buildings at $622. Structural characteristics can influence design fees, although to a lesser degree than they affect installation costs.

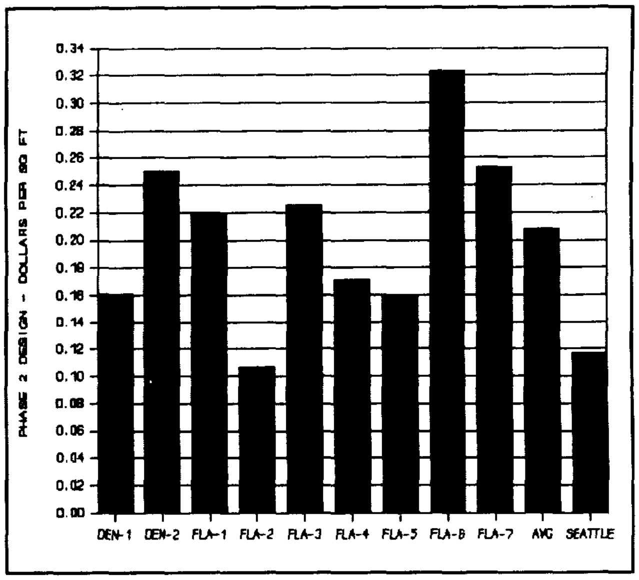

Figure 8. Design Costs for Phase II Structures, Dollars Per Square Foot.

Mechanical Systems Costs

Mechanical systems basically includes most of the installation - all plumbing, water service connections, sprinkler heads, flow switches, etc. as well as installation labor for these components - hence, the largest share of the reported costs fell into this category. Figure 9 shows that about $2.5O/square foot was the average dollars paid for mechanical systems for the Phase II sites (excluding Seattle). While the construction costs for providing new water service at the Denver sites may have accounted for their high figures, new service was also installed ‘at FLA-5 and FLA-6 without major expense. The average cost for mechanical services in Florida was $1.58 square foot. FLA-4 was a pump and storage installation at a rural home not on the city water system, which raised the mechanical systems cost.

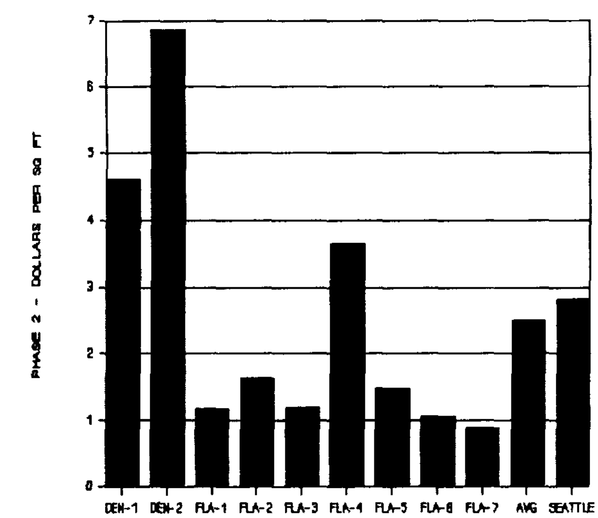

Figure 9. Costs for Mechanical Systems in Phase II Buildings, Dollars Per Square Foot.

Water Department and Other Fees

Despite nonexistent or trivial fees in five-of the Florida sites, the average water fee imposed for the Phase II sites was nearly $300, excluding Seattle. The sprinkler water supply in Seattle was tied in to the existing domestic water service downstream of the meter, so the reported $2,237 in fees was reported to be for purposes other than water. Similarly, as discussed in detail earlier, water department fees for the Denver projects were renegotiated. Reported fees of $678 and $805 at those two sites were not related to water service. Figure 10 summarizes the costs for various fees, as reported by the contractors.

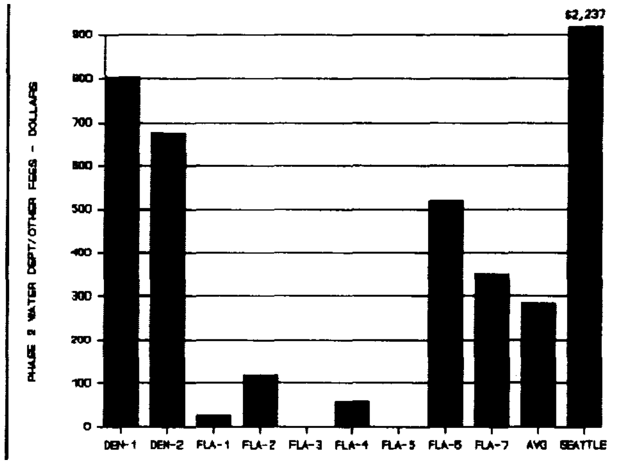

Figure 10. Water Department and Other Fees for Phase II sites, Dollars.

Permits, Plan Reviews and Inspections

Average cost of the permitting and plan review costs reported was $79 as indicated in Figure 11. Seattle reported costs in this category of $281. No costs were reported in this category by FLA-3 and FLA4.

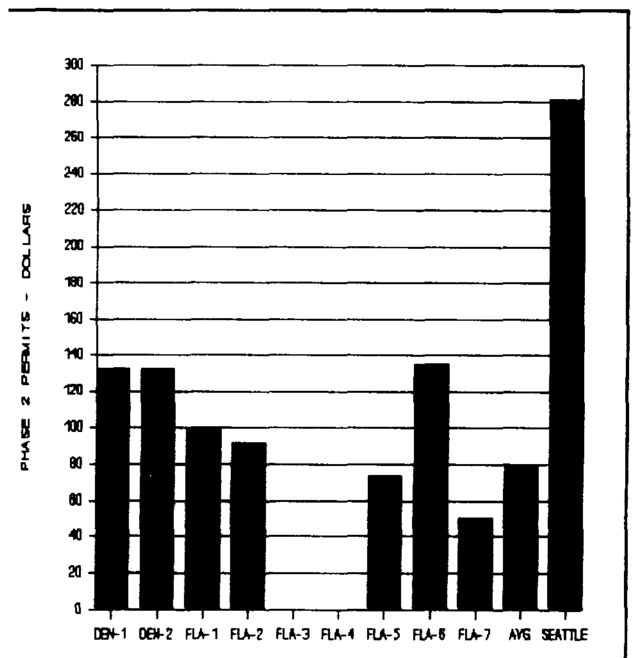

Figure 11. Costs For Permits and Plan Reviews for Phase II Buildings, Dollars.

Operation and Maintenance Costs

Buildings equipped with fire sprinklers can be subject to various costs whether or not a fire actually occurs. Operational costs may include water department fees, yearly inspections, testing and maintenance, a monitoring and response service, increased property taxes reflecting a higher tax assessment, damage from leakage or accidental discharge, and financing charges when borrowed funds are used to pay for the sprinkler system. Further, in the event of sprinkler activation there will be costs for replacement of heads, metered water consumption (if applicable), and any necessary repairs due to water damage.

Nominal operating costs were known to exist for three of the Phase II buildings. In Denver, the home owners will be charged a $l/month standby fee for dedicated water service to the sprinkler systems. In Jefferson County, Florida, the pump and storage system installed there should receive annual maintenance and inspection. This is estimated to be on the order of $5O/year for one l-hour service call each year, not including materials. This was a concern to the home owner and project staff. Inevitable service calls on the booster/storage package for yearly testing and occasional repairs would entail expenses that the homeowner may not be able or willing to pay, especially on a recurring basis. We expect that annual inspections will be required on most or all NFPA-13D systems and the exact cost to the home owners for this will probably vary according to local jurisdiction.

While the rehabilitated condition of the buildings may cause a reassessment and subsequently higher tax bill, none of the owners could estimate what, if any, property tax increase was directly attributable to the presence of the fire sprinkler systems. The federal grants that paid for the installations precluded any significant interest or financing charges for these systems.

ECONOMIC BENEFITS TO BUILDING OWNERS INSTALLING FIRE SPRINKLER SYSTEMS

The principal economic benefits from any residential fire protection strategy result from the reductions or potential reductions in fire losses. The economic benefits may be reflected in reduced property insurance premiums, reduced property damage costs, and construction variances that may accompany a sprinkler system. Based on information gathered in the course of this project, the financial returns on fire sprinkler systems are generally more substantial for multifamily building owners than owners of private homes.

Property Insurance Discount

Table IV has been repeated from the Phase I report for information purposes and includes only those multifamily buildings; Seattle has been added as well. All five buildings received some degree of savings on property insurance premiums ranging from 5 to 50 percent. In some cases updated policies on the rehabilitated buildings were less expensive than the original policy; these insurance premium reductions were due, in part, to the improved general conditions of the dwelling, and in part to the installation of fire sprinklers.

Table IV. Property Insurance Information As Reported By Building Owners And Insurance Agents.

FIRE SPRINKLERS AND PROPERTY INSURANCE

	BOSTON	HARRISBURG	PR GEO COUNTY	ST. LOUIS	SEATTLE
DISCOUNT	45%	35%	5%	20%	50%
REPLACEMENT	100%	100%	100%	65-70%	N/A
COVERAGE DEDUCTIBLE	$1,000	$500	$250	$500	N/A

SOURCE: Building Owner and/or Insurance Company Representative.

Conversely, no significant reductions were reported by the single-family home owners. A pending insurance premium reduction was reported by the home owner in St. Petersburg. In Austin it was learned that the Texas State Board of Insurance does not currently recognize

NFPA-13D systems as property-protection systems, thus does not enforce rate discounts on home owner insurance policies. The justification for this policy is a literal interpretation of NFPA-13D that the standard is based on life safety criteria rather than property protection. Hence, NFPA-13D does not apply to home owner policies that insure against property losses. (They do however endorse premium discounts for NFPA-13 sprinkler systems.) The Board, as in many other states, issues compulsory maximums for insurance premiums. It was noted that they would not prohibit underwriters from offering discounts for NFPA-13D systems if they elect to do so.

In general, rate decisions in the insurance industry are guided by the Insurance Services Office (ISO), strictly an advisory organization. IS0 has recommended that companies offer discounts of up to 10 percent on fire insurance policies for rental structures that have “partial” sprinkler coverage and up to 20 percent for buildings that have “full” coverage. Insurance companies are free to offer higher or lower discounts within their local regulatory guidelines. The discount on any individual policy is determined on a case-by-case basis, particularly for large policies, and is dependent on the evaluation of an underwriter. An underwriter bases actual rates on the reliability, maintainability, and expected performance of a sprinkler system, in addition to standard risk factors such as the local community fire protection rating and distance to the nearest fire hydrant and fire station.

Reduced Property Damage Costs

Many fire insurance policies provide only partial coverage. That is, an owner may get only partial reimbursement because of a deductible, low policy limits, or the type of coverage (e.g., full replacement cost or less). An owner with only partial coverage will benefit from any system that reduces the likelihood of property damage from fire. Table IV shows that in three of the jurisdictions the building insurance policies cover full replacement value. The exception was St. Louis where the insurance policy only covers the value of the rehabilitation, estimated to be 65 to 79 percent of the replacement cost of the building. The table also provides the deductibles applied at each site.

Construction Alternatives

Construction variances were granted in St. Louis and Seattle as a result of the installation of fire sprinklers. St. Louis uses the Building Officials and Code Administrators (BOCA) model building code, which requires emergency egress from the third floor of three-story buildings as well as 60-minute fire wall construction in stairways. For the sprinklered building at 2102 Lafayette Avenue, the building commissioner waived both requirements. The Research Center staff has estimated that $4,650 was saved by these exceptions: $4,500 by omitting the egress, and $150 by the reduction in stairwell wall rating. In Seattle, an attic space was allowed as a rentable space by building inspectors because the space was sprinklered. Because the space had only one means of egress, the space was not deemed habitable otherwise. That unit currently rents for $400 per month, providing additional annual income to the owner of up to $4,800.

Improved Marketability of Units With Sprinklers

The fact that occupants of units with fire sprinklers are exposed to a reduced probability of death or injury from fire may be a marketable benefit. In communities participating in this project, fire losses tended to be disproportionately larger than the percentage of the population that actually reside in those neighborhoods. In four communities, the population residing in those neighborhoods suggested an adequate market base for “selling” the “reduced probability” feature. Some renters, may qualify for more tangible benefits through reductions in their own personal property insurance, or “renter’s insurance,” due to the presence of fire sprinklers in their unit. The benefit of reduced probability of death or injury to tenants resulting from presence of fire sprinklers may accrue to building owners through increases in rental income. The incremental increase in rents that can be justified by the sprinkler system was not studied in this project and is not clearly known.

Multifamily building owners often cited the inherent need to keep rents down in low-income neighborhoods. Further, they argued that the presumed marketing advantages gained from the fire sprinkler system, those discussed above, were largely intangible and could not be reliably predicted. Thus, the fire sprinklers represented an additional payout, with an uncertain rate of return.

PROBLEMS AND RECOMMENDED SOLUTIONS

Based on the experiences and knowledge gained in Phases I and II of the project, the Research Center observed several recurring technical and regulatory barriers that impeded the installation of RFS in these rehabilitation projects. Below is a summary of the problems encountered with recommended approaches to alleviating those barriers.

- *Problem: Lack of Interdepartmental Familiarity and Framework for RFS Implementation.* The installation of fire sprinklers in HUD-funded rehabilitations typically involves at least three municipal authorities: the community development, fire, and water departments. All of these agencies have a role in planning the installation of fire sprinklers in federally subsidized rehabilitation projects. Sometimes nonprofit construction organizations are involved too. A lack of familiarity with the procedures and regulations of the various municipal departments often impeded the timely installation of RFS in the selected buildings. Often the inclusion of RFS in rehab projects was unfamiliar ground for those involved with the construction and inspection process. It was observed, in some jurisdictions, that interdepartmental communication was not usual practice, or effectively nonexistent.

  Recommendation: Municipal departments should review and understand the appropriate procedures for installation of RFS in rehabilitation projects in their jurisdictions. Opportunities should be made available for city employees to become familiar with the personnel and procedures of other city departments that are involved in RFS installation, In addition, local administrators and construction personnel involved with rehab programs must be made familiar with basic technical issues involved in RFS systems. Initiatives by local fire departments are most appropriate in this regard. At these nine sites, for example, this project was instrumental in establishing the needed interdepartmental relationships. Hence, in future installations the process will be more familiar to those involved and should move more smoothly. Other local fire departments may consider sponsoring similar pilot projects so that appropriate procedures can be "walked through", understood, and adopted.

- *Problem: Shortage of NFPA-13D Installers.* The affordability of RFS in residential dwellings depends on reasonable installation costs. Experiences in this project suggest that the fire sprinkler industry is comprised predominantly of contractors who specialize in large NFPA-13'commercial systems; those that customarily do 13D systems are much fewer in number. Either the profit margins or level of activity in small NFPA-13D residential systems are not adequate to attract the large operations into the residential market, or their overhead costs do not allow them to deliver the small jobs at reasonable prices. For whatever reasons, it was apparent that many sprinkler installers are not enthusiastic about single family RFS systems. The relative shortage of 13D installers in some localities creates a noncompetitive environment. Lack of competition neutralizes a key mechanism responsible for holding prices down.

  Recommendation: Make the opportunities that may exist in residential RFS available to a wider range of installers. Licensed plumbers, for example, possess the mechanical skills for installing NFPA-13D and 13R systems but lack design expertise. Plumbers should be made aware of the opportunities for business expansion that may exist in RFS installations. Municipal authorities could offer and promote training programs to bring plumbers into the RFS arena, or work with sponsors who have already developed programs. Activity in this direction has been seen, particularly in the state of Florida where a limited certification has been established for 13-D installers. Jurisdictions might consider a certification "option" in their ordinary master plumber licensing procedures, whereby an NFPA-13D adjunct is added to the licensing requirements. Plumbers who select the option, receive the necessary training, and pass local testing requirements would then be licensed to do NFPA-13D installations.

- *Problem: Inadequate Existing Water Service.* In single family homes like those participating in Phase II of this project, the existing water service is typically 3/4 inch. While this may be perfectly adequate for even new homes, a 3/4-inch service very often cannot provide the water volume and pressure requirements of a water-based fire suppression system, especially when city water pressures in the neighborhood are low or borderline, or if buildings are multistoried. A simple 2-story single family home can be difficult to sprinkler if local pressures are below about 50 psi. Ordinarily, the design of a sprinkler involves constant trade-offs between pressure losses and pipe sizes. When pipe sizes are reduced to bring costs down, higher pressure losses are the result. In many cases, reasonable increases in pipe sizes are not enough to provide the hydraulic requirements of the system; then upgraded water service is necessary.

At these sites, installation of RFS required additional connections to the water main, or upsizing of the existing connection. This process can be expensive due to water department policies and fees that accompany those hook-ups. Water department fee structures as they pertain to new taps and upgraded service can render residential sprinkler systems uneconomical, particularly in smaller buildings where those costs represent a larger proportion of the total cost. In addition, water departments lacked experience in dealing with retrofitted RFS, especially in single family detached homes. The uncertainty of all parties with respect to fees and procedure required that the sites be handled on a case-by-case basis.

Recommendation: Local water departments need to reconsider the impact of policy and fee structures on the retrofitting of RFS in residential buildings occupied by high-risk populations. Some water departments expressed a willingness to do so, but were awaiting opportunities to formally study proposals. The local fire departments are best positioned to initiate that activity or renegotiate those policies, and set an appropriate course of action in their jurisdiction.

- *Problem: Unbalanced Priorities.* Within some fire departments, there are policies based on the assumption that some protection in domestic dwellings is not better than no protection. This policy can intimidate building owners that may otherwise have considered adding fire suppression systems to their rehabilitation plans. The use of plastics in residential systems, for example, is still not recognized by some jurisdictions. The policies of insurance regulators may be a contributing factor.

  Recommendation: Fire officials and local governments should consider the need to the affordability concerns of building owners and the fire protection concerns of their communities when legislating sprinkler standards. This is particularly relevant in the rehabilitation of low-income housing where profits from rents may already be marginal, and building owners lack sufficient incentive. If the costs of these systems decrease over time, the need to rely on financial incentives for cost effectiveness will diminish. But, when the major cost drivers remain inflated, incentives will continue to be necessary in order to make RFS a voluntary addition to rehabilitation work plans.

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Tom McManus
Denver Department of Fire
Fire Prevention Bureau
745 N. Colfax Avenue
Denver, CO 80204
(303) 575-5522

BUILDING LOCATIONS:

3145 Gaylord Street
3713 Gaylord Street
Denver, CO

BUILDING OWNER: Owner occupied homes

BUILDING DESCRIPTION:

Woodframe, single-family
l-story detached house
with basement

SPRINKLER SYSTEM: NFPA 13D

SYSTEM DESIGN & INSTALLATION CONTRACTOR:

AAA Fire Sprinkler, Inc.
355 East 55th Avenue
Denver, CO 80216
Contact: Pete Froyen
(303) 293-9202

COMMUNITY: State of Florida

CONTACT: Rick Ruh
Division of State Fire Marshall
Bureau of Fire Prevention
Plans Review Section
J. Edwin Larson Building
Suite 591
Tallahassee, FL 32399-0300
(904)488-2449

BUILDING LOCATION: Cities of Quincy, Tampa, St. Petersburg, Orange Park, and Jefferson County
(Seven Buildings, Total)

BUILDING OWNER: Owner occupied homes

BUILDING DESCRIPTION: All single-family, detached homes, wood frame; six l-story, one 2-story;

SPRINKLER SYSTEM: All NFPA-13D;
Including one well-water system

SYSTEM DESIGN & INSTALLATION: Members of Florida Fire Sprinkler Association
Headquarters
Tampa, Florida
Contact: Mr. Chuck DUnn
(813) 932-7811

COMMUNITY: Seattle, Washington

CONTACT: Chief Gregory M. Dean
Seattle Fire Department
301 2nd Avenue South
Seattle, WA 98104
(206) 386- 1450

Janet W. MacKenzie
Seattle Department
of Community Development
400 Yesler Way
Seattle, WA 98104
(206)684-0350

BUILDING LOCATION: Victoria Apartments
Denny Way &
14th Avenue East
Capitol Hill
Seattle, WA

BLDG. OWNER & DEVELOPER: Mr. Randy Martens
Mr. William Chan

TENANTS: Moderate Income

BUILDING DESCRIPT.: Woodframe, 10 unit, single-family conversion, 4 stories and basement

SPRINKLER SYSTEM: NFPA-13D. All Copper.

DESIGN & INSTALL.: James Buchanan; and
Ms. Audrey Vanhorne
Van Horne & Van Horne Architects
Seattle, WA
(206) 324-1980
Larry Meyers
LNW Fire Protection System
Redmond, WA
206-867-1861

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