Cost and Benefit Considerations
of a Residential Sprinkler Ordinance
in Oshkosh, Wisconsin

Kevin Gerarden

Analytical Approaches to Public Fire Protection
32 FST 381
John W. Glass
March 20, 2010
March 20, 2010

Hon. Paul Esslinger, Mayor
203 Church Avenue
Oshkosh, WI 54901

Your Honor:

Attached for your consideration you will find the report of the Residential Sprinkler Task Force of the Oshkosh Fire Department. This report represents the efforts of the Task Force members in their examination of the proposal to enact a residential fire sprinkler ordinance for the City of Oshkosh. Copies of this report are also being provided to the members of the Common Council.

I would especially like to invite you to access the online resources listed in the bibliography of the report. Many of these web pages are interactive and multimedia items that underscore the findings of the Task Force.

You may be assured of my willingness to meet with you at your convenience to discuss or explain any of the content of the report. Please feel free to extend the same invitation to the Council.

Sincerely,

Lt. Kevin Gerarden, Chairman
Residential Sprinkler Task Force
INTRODUCTION

For decades, automatic sprinkler systems have been a common fire protection feature of commercial and industrial property. Their effectiveness in controlling and suppressing fires is well established. In recent years, sprinkler protection has been adapted to residential use. The primary incentive to provide sprinkler protection in commercial buildings comes from the need to protect profitability and business continuity, and is suitably reinforced by incentives from insurance carriers. By contrast, the decision to protect one’s own home is usually less informed, and often subject to no prominent incentives such as may be found in the commercial setting. Communities with a proactive approach to life and fire safety may adopt ordinances that require sprinkler protection for residential properties, thus transforming that decision into an obligation of living in those communities. This report examines in detail both the costs and benefits of residential sprinklers, as it relates to proposal of an ordinance requiring their installation in new residences.

Statement of Purpose

The use of residential automatic sprinklers, as required and administered by a municipal ordinance, is an investment in safe housing that will yield measurable benefits accruing to the occupants, the property owners, the city government, and the community as a whole.

DISCUSSION

Automatic sprinkler systems are comprised of a network of water pipes extended throughout a structure, similar to the normal potable plumbing system. Fitted to these pipes are sprinkler heads, each of which typically protects an area of approximately 12 feet square or larger. The sprinkler head consists of an orifice, its plug or cover, and a heat-sensitive element
designed to release at a set temperature (135-170° F. is common). Only the head or heads closest to the heat generated by the fire will open. Once thus activated, a sprinkler head will discharge water at a typical design rate of 18 to 25 gallons per minute. (Cote, 2003) These two operational principles are important to understand, particularly due to myths and misconceptions often held by the public, who sometimes will envision an entire system activating with little or no provocation. The use of unrealistic portrayals of sprinkler activation by television and cinema (usually as a plot device) tend to perpetuate these myths. (HFSC, 2009) Once cleared of such misinformation, the discussion of residential sprinklers can be best evaluated in terms of costs and benefits.

**Costs**

Recently completed research outlines the various costs associated with the installation of sprinkler systems in new residential properties, expressed in dollars per sprinklered square foot. These figures can vary widely, depending on the many variables at work in the community examined. (Newport Partners, 2008) Figure 1 summarizes these costs for ten communities studied.

![Sprinkler System Costs to the Homebuilder(S/Sprinklered SF)](image)

Figure 1. (Newport Partners, 2008)
Installation costs for sprinkler protection in these communities range from $0.38 to $3.66 per sprinklered square foot, with a mean for all properties of $1.61. The variables identified (and the communities in which they were found) include: Sprinkler ordinance status (sorting criteria in the chart); Well-water systems supplying sprinklers (Fort Collins and Carroll County); copper piping (Fort Collins); high regulatory costs (Fort Collins and Wilsonville); and requirements for attic/garage installation (Pleasant View, San Clemente, North Andover, and Huntley). (Newport Partners, 2008)

Due in great part to the lack of sprinkler ordinances in Oshkosh and surrounding communities, installation of residential sprinklers are relatively rare, thus making local cost figures more difficult to average. Informal inquiry reveals that those homeowners seeking sprinkler protection can expect to pay $2.50 to $4.75 per square foot; with the typical client protecting a home valued in excess of one million dollars. (Chapman, 2010)

While some of the variables affecting cost are dependent on materials used and existing/emerging technology, there are costs associated with sprinkler installation that are based on the regulatory policies of the authority having jurisdiction (AHJ). Water meter charges, inspection fees, and other requirements can add to the costs borne by the property owner. This impact can be lessened by provisions in the ordinance that support the effort, as in the waiving of new meter charges, or an outright property tax credit as is seen in Figure 1 (Wilsonville, OR). The very presence of a sprinkler ordinance tends to hold system costs down, by extending the effect of competition when all builders must include sprinkler systems in their bids.

**Benefits**

The benefits to be derived from sprinkler protection are rooted in the ability of sprinklers to detect and to suppress or control a fire during its incipient stage, before it creates a significant
threat to life safety, and prior to flashover, after which the majority of fire spread and damage occurs. Experiments performed on fires set in identically configured and furnished rooms, quantify the effectiveness of sprinklers in controlling fires early in their development. (Madrzykowski & al., 2004) (UL, 2010) Data from one such experiment is presented in Figure 2 (Madrzykowski & al., 2004, Figure 65), outlining temperatures in each of one sprinklered and two unsprinklered fire rooms. The divergence in temperature curves, as may be expected, occurs approximately at the point in time during the fire in Day Room 1 when the sprinkler system activates (137 seconds). These results are representative of the effects of sprinkler performance on total heat flux, smoke production, and fire spread. (UL, 2010)

![Figure 2.](image)

**Figure 65.** Day room temperature comparisons for experiments 1, 2, and 3 at 0.61 m below ceiling, TC array 7.

**Figure 2.** (Madrzykowski & al., 2004)
Fires suppressed by sprinkler systems translate into:

- Higher rates of survivability (at or near 100%),
- Reduced occurrence and/or severity of injuries,
- Reduced levels of property damage.

Table 4-1. Calculation of Present Value Benefits of Wet-Pipe Sprinkler Systems.

<table>
<thead>
<tr>
<th>Input Parameters</th>
<th>Calculated Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of Fire Occurrence</td>
<td>Value of Statistical Life (5 million)</td>
</tr>
<tr>
<td>Reduction in Annual Probability ofFLASH, Ovens, Fires, Between Dwellings with Only Smoke Alarms and a Sprinkler System</td>
<td>7.94</td>
</tr>
<tr>
<td>0.0086</td>
<td>226.68</td>
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<tr>
<td>1.0000</td>
<td>3725.57</td>
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<tr>
<td>Expected Number of Fatalities, Per Fire, in Dwellings with Only Smoke Alarms</td>
<td>0.0082</td>
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<tr>
<td>Fatalities Averted</td>
<td>3725.57</td>
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<tr>
<td>Probability of Fire Occurrence</td>
<td>Value of Statistical Injury ($ million)</td>
</tr>
<tr>
<td>Reduction in Annual Probability of Injury, Ovens, Fires, Between Dwellings with Only Smoke Alarms and a Sprinkler System</td>
<td>171.60</td>
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<tr>
<td>0.0869</td>
<td>14.29</td>
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<tr>
<td>0.5879</td>
<td>224.94</td>
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<tr>
<td>Expected Number of Injuries, Per Fire, in Dwellings with Only Smoke Alarms</td>
<td>0.0463</td>
</tr>
<tr>
<td>Injuries Averted</td>
<td>224.94</td>
</tr>
<tr>
<td>Probability of Fire Occurrence</td>
<td>Value of Statistical Indirect Property Loss, Per Fire, in Dwellings with Only Smoke Alarms</td>
</tr>
<tr>
<td>Reduction in Annual Probability of Direct Unassigned Property Loss, Ovens, Fires, Between Dwellings with Only Smoke Alarms and a Sprinkler System</td>
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<td>0.1000</td>
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<td>Expected Direct Unassigned Property Loss, Per Fire, in Dwellings with Only Smoke Alarms</td>
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<td>Direct Property Losses Averted</td>
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<td>Probability of Fire Occurrence</td>
<td>Value of Statistical Indirect Cost, Per Fire, Between Dwellings with Only Smoke Alarms and a Sprinkler System</td>
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<td>Reduction in Annual Probability of Indirect Cost, Ovens, Fires, Between Dwellings with Only Smoke Alarms and a Sprinkler System</td>
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<td>Expected Indirect Cost, Per Fire, in Dwellings with Only Smoke Alarms</td>
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<td>Indirect Costs Averted</td>
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<td>Insurance Credit</td>
<td>Value of Statistical Insurance Premium for Sprinkler System</td>
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<td>Annual Household Insurance Premium for Sprinkler System</td>
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<td>Total Present Value</td>
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Note: Annual benefits are expressed in constant 2005 dollars. Present value benefits are based on a 30-year study period. Input parameters shown are rounded.

Table 1. (Butry & al., 2007)

In a study funded by the US Fire Administration (USFA), data gathered by the National Fire Incident Reporting System (NFIRS) and taken from the survey of the National Fire Protection Association (NFPA) have been analyzed and quantified. Benefits of sprinkler use are calculated over a 30-year period, employing cumulative probabilities of a given homeowner experiencing a fire, the probablities of death, injury, and property damage, and their reduction attributable to sprinkler activation. The combined monetary values of these benefits are greater than the estimated costs of installing a prototypical system, showing a “bottom line” net benefit.
Table 1 summarizes these findings. (Butry et al., 2007) Among the benefits listed in the table is a reduction in homeowners’ insurance premiums, averaged at 8% for the study.

Actual performance histories of the benefits of residential sprinkler protection can be examined in the studies of Scottsdale, Arizona (Ford, 1997) and Prince George’s County, Maryland. (Siarnecki, 2001) These jurisdictions have had residential sprinkler ordinances in place for ten or more years, together with considerable growth in residential property. Fire data collected from these communities confirm that, although each community sustained fire fatalities over the period studied, none of them occurred in sprinklered residences. Additionally, average per-fire property damage was considerably less in sprinklered versus unsprinklered properties.

Concerns with water damage from sprinkler discharge were addressed by the Scottsdale estimate that sprinklers use less water overall than the typical quantities applied by manual suppression efforts of the fire department.

Data from the Scottsdale and Prince George’s studies, together with samples taken from Oshkosh Fire Department (OFD) records, are shown in Figure 3. It should be noted that, due to differences in property values and years studied, these are not direct comparisons, but are offered for purposes of perspective. Additionally, while no fatalities occurred in sprinklered properties, the lower fatality rate (per thousand population) in Scottsdale and Prince George’s County can be explained by the assumption that a substantial portion of the population in each of those two communities dwell in sprinklered housing, thereby reducing the rate for the entire community.

Builders and developers may benefit from including sprinklers in the form of “trade-ups” – variances granted by the AHJ to the developer in recognition of the decreased severity of fires likely to occur in sprinklered properties. These variances may include increased building and living-unit density, street configurations, and hydrant spacing. These options can create value-
Figure 3A. (Ford, 1997) (Siamecki, 2001)
added features in the developed property. (HFSC, 2009)

The municipal government may benefit from trade-ups, when enhanced property values in new properties and developments enable higher property-tax revenues (although the city may relieve the tax burden for the installing owner by deferring the assessment until resale of the property). Municipalities may also benefit, as in the case of Scottsdale, by being able to serve a growing community without necessitating a commensurate growth in its fire department budget.

Finally, the community at large benefits from its members’ avoiding the economic and social disruption created by residential fires. While difficult to quantify precisely, and sometimes incorporated into estimates of “indirect costs,” the losses borne by individual fire victims affect their relationships with their families, social networks, and employers. When sprinklers hold fire losses to manageable levels, continuity of these relationships is preserved.

**Relevant Trends**

While the emergence of observable performance in Scottsdale and Prince George’s County were made possible by robust growth in residential building, the current rate of growth in Oshkosh, Wisconsin is unlikely to yield such dramatic results. Nonetheless, slow growth must not be used as an excuse to disregard future needs for fire-safe housing. The benefits of sprinkler protection are of particular importance when viewed in light of converging trends affecting the city of Oshkosh. Among these trends are:

- The development of residential neighborhoods in the north and west ends of the city, and the annexation of portions of the Towns of Oshkosh, Algoma, Black Wolf, and Nekimi for development purposes. (City of Oshkosh, 2005)
- The increased use of lightweight building components in residential construction, and increased recognition of their vulnerabilities under fire conditions by firefighters.
Figure 4. Station Coverage Map.
The continued increase in synthetic materials in interior furnishings and contents, resulting in higher potential heat release rates in building fires.

Continued reliance on the fire department to provide emergency medical service (EMS), and increased demands for that service as the population ages. (CDC, 2003)

The effects of these trends may include any combination of:

- reduced fire company availability for structure fires,
- longer travel distances for available companies (thus increasing response times),
- shorter times to either flashover or structural failure during fires, and
- longer alarm-to-combat times for assembled fire suppression forces.

An example can be found on the map in Figure 4, where two of the existing fire stations serve the north and west extremities of the city. While first-due response times in these areas average three to five minutes, alarm-to-combat times for structure fires are dependent on the arrival of the second- and/or third-due fire companies, which may average from 7 to 8.5 minutes. Coincidentally, this approximates the point in fire development when flashover becomes likely. Sprinkler protection, therefore, can be a crucial factor for those properties that are both newest and most remotely located in the city.

CONCLUSION AND RECOMMENDATIONS

The cost of installing residential sprinklers is borne primarily by the property owner, and to a lesser extent, by the community. The benefits of sprinkler protection accrue primarily to those property owners who sustain a fire in the dwellings they own, but the entire community also benefits from the diminishment of that fire’s impact. The mandate imposed by a sprinkler
ordinance, like that of public funding for fire suppression forces, ensures that everyone lends support to the protective measure that someone will eventually need.

A parallel case of cost and benefit in the area of fire protection can be seen in the building construction of most of downtown Oshkosh. Early in its history, the city repeatedly sustained widespread damage by a series of conflagrations, the last and most extensive occurring in 1874. In the aftermath of that disaster, the City Council established the building requirements for the “Fire Limits” of the city, which included exterior walls of noncombustible materials and other loss-limiting features. (Metz, 1999) The longevity of the buildings within these boundaries is observable and impressive. Experience has estimated the rate of fire loss as a single building or less per decade, despite considerable fuel loading and zero clearance between most of the buildings in the district. The costs incurred by the requirements imposed by the city’s fire limits have been well recovered in the century or more of these buildings’ existence.

The ordinance establishing fire limits was a reactive measure prompted by the repeated destruction of vulnerable property. By contrast, the ordinance studied here represents a proactive effort to mitigate the destructive potential of converging trends affecting our city’s newest buildings.

The recommendations of this report are as follows:

- That the government of the City of Oshkosh actively pursue the adoption of an ordinance that requires automatic fire sprinkler protection in all new residential construction;

- That the ordinance incorporate the requirements of the current editions of National Fire Protection Association Standard 13D and Standard 13R;
• That the ordinance adopted be administered as part of the building permit and inspection process to ensure compliance;

• That no provisions of the ordinance create new or undue regulatory costs or other extraordinary burdens for the property owner.

The city would do well to avoid, wherever possible, the role of taskmaster in this endeavor, and by reason of its potential to share in the benefits of sprinkler protection, pursue the role of an enabling partner. Because of the conservative rate of growth in the community, it is likely that the benefits of such an ordinance will not be plainly evident for years or even decades. However gradually that process takes place, the sooner it is begun, the sooner the benefits will emerge.

BIBLIOGRAPHY


