

An Analysis of Automatic Sprinkler System Reliability Using Current Data

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Abstract

With the added detail provided in the National Fire Incident Reporting System (NFIRS) Version 5.0, it is now possible to develop much better estimates of sprinkler reliability. With pre-1999 data, past reports estimated that sprinklers failed to operate in 16% of structure fires large enough to activate sprinklers. The old data could not separate (a) fires in the sprinkler coverage area from fires outside the coverage area (e.g., in properties with partial systems), (b) sprinklers from other automatic extinguishing systems, and (c) human error from mechanical and other equipment problems.

The new estimates are that sprinklers failed to operate in 7% of structure fires (reported in NFIRS 5.0 in 1999-2002, after adjustment for errors in coding partial systems). The percentage varies from a low of 2% for apartments to a high of 14% for storage properties.

The percentage rises to 9% if all types of automatic extinguishing equipment are included. This primarily reflects dry chemical systems used in public assembly properties.

Two-thirds (65%) of the sprinkler failures to operate were because the system had been shut off before the fire. Another one-sixth (16%) occurred because manual intervention defeated the system, for example, by shutting off the sprinklers prematurely. Lack of maintenance accounted for 11% of the sprinkler failures to operate and 5% occurred because the wrong type of system was present. Nearly all failures were therefore entirely or primarily problems of human error. Only 3% involved damage to system components.

When sprinklers operated, they were deemed effective in 96% of the fires. When they were not effective, over half the time (55%) it was because water did not reach the fire. Most of the other cases of ineffective performance (31% of the total) occurred because not enough water was released. Inappropriate systems accounted for 7% of the cases, system component damage for 5%, and manual intervention defeating for 2%.

Effectiveness tended to be associated with a small number of sprinklers operating. When only 1 sprinkler operated, performance was effective 95% of the time. This fell slightly to 94% when 2 sprinklers operated, to 91% for 3 sprinklers, 89% for 4-10 sprinklers, and 81% for more than 10 sprinklers.

Detail captured in national fire incident databases

Prior to 1999 (NFIRS Version 4.1), automatic extinguishing system performance coding for fires had these choices:

- 1 Equipment operated
- 2 Equipment should have operated but did not
- 3 Equipment present, but fire too small to require operation
- 8 No equipment present in room or space of fire origin
- 9 Unclassified performance
- 0 Unknown performance

NFPA estimated the likelihood that sprinklers were operational when fire occurred as fires coded 1 (operated) divided by fires coded 1 or 2, thereby excluding fires deemed too small to activate an operational sprinkler. The last calculation before the change in coding was for 1989-1998 and showed an average for all structures of 16% sprinklers non-operational. If the same formula were used on 1999-2002 data, the result would be an estimate of 18% sprinklers non-operational.

This calculation has always had some serious limitations that reduce its validity as a best estimate of sprinkler operability. First, it did not distinguish sprinklers from other types of systems, most notably the dry chemical systems widely used for hazard protection of commercial ranges. Second, there was anecdotal evidence to suggest that codes 1-3 were often recorded for partial-coverage sprinkler systems that in fact had no coverage in the room or space of fire origin.

Beginning in 1999, the new NFIRS Version 5.0 includes two new data elements that can be used to refine the estimates. First, type of equipment is now coded, which permits sprinklers to be separated from other extinguishing systems. Second, reasons for non-operation or ineffectiveness can now be identified.

In parallel with the advent of NFIRS Version 5.0, NFPA conducted a special study, under sponsorship of the National Fire Sprinkler Association (NFSA), with Prince George's County, Maryland, an urbanized county adjacent to Washington, DC. The county has a long history of strong support for the use of fire sprinklers, including one of the oldest and most comprehensive home sprinkler ordinances as well as a history of collecting special data on sprinkler performance.

In this special study, NFPA trained county officers in the use of a special incident form, which would provide much more detail on the equipment, its location, and reasons for unsatisfactory performance in fire incidents, as well as data not normally collected at all on water release incidents not involving unwanted fires. The project was recently concluded, and the results indicated that the extra detail was very rarely provided. Most incidents were coded only with detail that could have been obtained with the new coding in NFIRS Version 5.0. Also, a parallel exercise, using well-trained coders on NFPA staff working off the NFPA database of reported fires, found the agreement between coders on the extra details was not very good. Therefore, the recommendation from the project was to focus on the new analysis now made possible with NFIRS Version 5.0. That is the subject of the remainder of this paper.

Type of automatic extinguishing equipment reported present in fires

Table 1 shows a breakdown by property type of the percentage of reported fires with automatic extinguishing equipment present that had each type of equipment. Percentage calculations are based only on fires where automatic extinguishing system presence and type were reported.

Some type of sprinkler system was present in 88% of all structure fires and 96% of residential fires where an automatic extinguishing system was present.

Wet pipe sprinkler systems accounted for 75% of all systems (85% of residential) and so outnumbered dry pipe systems by 7-to-1 and outnumbered all other types of sprinklers by nearly 30-to-1.

Dry pipe sprinklers were most common in storage properties, where they accounted for 29% of systems compared to 68% for wet pipe sprinklers.

For public assembly properties, there was a 55% to 45% split between sprinkler systems and other systems, respectively. Dry chemical systems accounted for 34% of the systems present.

Eating and drinking establishments (the dominant part of public assembly) had a 43% to 57% split between sprinkler systems and other systems, respectively. Dry chemical systems accounted for 43% of total systems in eating and drinking establishments, or the same share as all sprinklers combined.

In Version 5.0 of NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. This field is not required if the fire did not begin within the designed range of the system.

Reconciling equipment performance with reasons for unsatisfactory performance

With the new data elements in NFIRS Version 5.0, it is now possible to separate unsatisfactory sprinkler performance into cases of failure to operate at all and failure to be effective. The list of reasons for unsatisfactory performance is the same for both types of performance, but some reasons only make sense for one or the other type of performance. Also, one reason – system not in area of fire – is supposed to mean “sprinkler not present” by the rules of the coding. Like “fire too small,” such cases are not regarded as fair tests of the operational status of a sprinkler system.

Therefore, part of our analysis of the new data involved recoding the reported performance so as to be compatible with the more detailed entry regarding reason. Also, cases with reason coded blank or unknown were proportionally allocated to avoid the dubious implicit assumption that the coded performance is correct if no reason is given for the performance.

Here are the rules used for recoding:

If Performance = Not Effective

And Reason =
System shut off
Not in area of fire

Then Change to:
Performance = Failed to operate
Presence = No; Performance not applicable

If Performance = Failed to Operate

And Reason =
Not enough agent
Agent didn't reach fire
Not in area of fire

Then Change to:
Performance = Not effective
Performance = Not effective
Presence = No; Performance not applicable

How often does automatic extinguishing equipment operate in fires?

Tables 2A and 2B show, respectively, the revised operability estimates by property, with Table 2A covering all extinguishing systems and Table 2B covering only sprinklers.

Our best estimate with this new data and associated analysis approach is that sprinklers fail to operate at 7% of reported fires large enough to activate an operational sprinkler system in the area of the fire.

As expected, the exclusions of systems other than sprinklers in Table 2B has its largest effect on public assembly statistics, which are dominated by fires in eating and drinking establishments. Dormitories are not listed because there has not yet been enough data for meaningful estimates, and in fact, many of the individual property classes have statistics based on a relatively small number of incidents.

When equipment fails to operate, what is the principal reason?

Tables 3A and 3B show the reasons for failure to operate, by property class and for all automatic extinguishing equipment vs. sprinklers only.

Two-thirds (65%) of failures to operate occur because the sprinklers were shut off. The likelihood of such failures can be greatly reduced through the use of programs that put highly noticeable tags on systems shut off for testing and maintenance. Valve supervision using a tamper switch connected to a central alarm monitoring station can also be helpful.

Training can also sharply reduce the likelihood of two other causes of failure – system defeating due to manual intervention (16%), lack of maintenance (11%), and installation of the wrong system for the hazard (5%). Only 0.2% of fires large enough to activate sprinklers that are in the coverage area show failure due to damage to components (0.2% equals 7% that failed times 3% of failures due to component damage).

A sprinkler system needs to be designed to fit the current needs of a property. If the property use changes, it is essential to review the adequacy of the sprinkler system. Even if the property use has not changed, the passage of time alone can dictate a review of the system.

When equipment is not effective, what are the principal reasons?

Tables 4A and 4B show all the adjusted performance percentages – operated and effective, operated but not effective, fire too small to activate operational sprinkler, and failed to operate – for the major property types and for all automatic extinguishing equipment vs. sprinklers only.

Tables 5A and 5B show the principal reasons for ineffectiveness for the major property types and for all automatic extinguishing equipment vs. sprinklers only. Roughly half the cases involved a failure of extinguishing agent to reach the fire. This can occur when fires are shielded (e.g., in racks when sprinklers are installed only at the ceiling), when sprinklers are blocked (e.g., by stock piled too high), or when sprinkler spray is unable to penetrate sufficiently far into the buoyant fire plume.

Roughly one-third of cases involved an insufficient release of agent. This could be coded because the sprinkler pipes were blocked or frozen (a system problem) or because the water supply was inadequate (a system environment problem).

A sprinkler system needs to be designed to fit the current needs of a property. If the property use changes, it is essential to review the adequacy of the sprinkler system. Even if the property use has not changed, the passage of time alone can dictate a review of the system. Even a well-maintained, complete, appropriate sprinkler system is not a magic wand. It requires the support of a well-considered integrated design for all the other elements of the building's fire protection.

Sprinkler effectiveness vs. number of sprinklers operating

The new coding also provides information on the number of sprinklers activating. Ten or fewer heads operated in 97% of the wet pipe system activations and 86% of the dry pipe activations. Table 6 shows the link between system effectiveness and number of sprinklers operating.

Dry-pipe systems are much more likely to open more than one sprinkler than wet-pipe systems (59% vs. 35% of fires). The likely reason is the time delay in tripping the dry-pipe valve and passing water through the piping to the opened sprinklers. The delay permits fire to spread, which can mean a larger fire, requiring and causing more sprinklers to activate.

When more than 1-2 sprinklers operate, this is often taken as an indication of less than ideal performance. When sprinklers were effective, more than two sprinklers opened in only one of six fires (17%). When sprinklers were not effective, more than two sprinklers opened in one of three fires (34%).

The percentage of fires where performance is deemed not effective increases as the number of sprinklers operating increases, rising from a low of 5% of fires when 1 sprinkler operates to a high of 19% when more than 10 sprinklers operate.

Table 1.
Type of Automatic Extinguishing System Reported
in Structure Fires Where Systems Were Present, by Property Use
1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments

Automatic Suppression Systems	All Properties	Public Assembly	[Eating & Drinking Establishments]	Educational	Health Care & Correctional
Wet pipe sprinkler	75%	46%	36%	86%	83%
Dry pipe sprinkler	11%	6%	4%	7%	12%
Other sprinkler system*	3%	3%	3%	2%	2%
Dry chemical system	7%	34%	43%	4%	1%
Carbon dioxide (CO2) system	1%	2%	3%	0%	0%
Foam system	0%	2%	3%	0%	0%
Halogen type system**	0%	1%	2%	0%	0%
Other special hazard system	2%	5%	7%	1%	1%
Sprinkler systems	88%	55%	43%	95%	98%
Other systems	12%	45%	57%	5%	2%

*Includes deluge and pre-action sprinkler systems.

**Includes non-halogenated suppression systems that operate on the same principle.

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Confined fires are excluded from this analysis. Percentages are based on fires in which type of system was known. "All properties" includes some properties not shown separately.

Eating and drinking establishments are part of public assembly.

Source: NFIRS and NFPA Survey.

Table 1. (Continued)
Type of Automatic Extinguishing System Reported
in Structure Fires Where Systems Were Present, by Property Use
1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments

Automatic Suppression Systems	All Residential	[One- and Two- Family Dwellings]	[Apartments]	[Hotels & Motels]	[Dormitories]
Wet pipe sprinkler	85%	68%	88%	85%	81%
Dry pipe sprinkler	8%	14%	5%	9%	9%
Other sprinkler system*	3%	6%	3%	3%	6%
Dry chemical system	2%	4%	2%	1%	0%
Carbon dioxide (CO2) system	0%	0%	0%	1%	1%
Foam system	0%	0%	0%	0%	0%
Halogen type system**	0%	0%	0%	0%	0%
Other special hazard system	2%	8%	2%	1%	2%
Sprinkler systems	96%	88%	96%	97%	96%
Other systems	4%	12%	4%	3%	4%

*Includes deluge and pre-action sprinkler systems.

**Includes non-halogenated suppression systems that operate on the same principle.

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Confined fires are excluded from this analysis. Percentages are based on fires in which type of system was known. "All properties" includes some properties not shown separately.

One- and two-family dwellings, apartments, hotels and motels, and dormitories, all are part of residential.

Source: NFIRS and NFPA survey.

Table 1. (Continued)
Type of Automatic Extinguishing System Reported
in Structure Fires Where Systems Were Present, by Property Use
1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments

Automatic Suppression Systems	Stores	Offices	Manufacturing	Storage
Wet pipe sprinkler	85%	86%	75%	68%
Dry pipe sprinkler	11%	9%	15%	29%
Other sprinkler system*	2%	3%	3%	1%
Dry chemical system	1%	0%	1%	1%
Carbon dioxide (CO2) system	0%	1%	3%	0%
Foam system	0%	0%	0%	0%
Halogen type system**	0%	0%	1%	0%
Other special hazard system	0%	0%	2%	1%
Sprinkler systems	98%	98%	93%	97%
Other systems	2%	2%	7%	3%

*Includes deluge and pre-action sprinkler systems.

**Includes non-halogenated suppression systems that operate on the same principle.

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Confined fires are excluded from this analysis. Percentages are based on fires in which type of system was known. "All properties" includes some properties not shown separately.

Source: NFIRS and NFPA survey.

Table 2.

**Automatic Extinguishing System Operationality in Structure Fires
When Fire Was Large Enough to Activate System
After Recoding of Errors Based on Reasons for Ineffectiveness or Failure to Operate,
by Property Use, 1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments**

A. All Automatic Extinguishing Systems

Property Use	Percent Where Sprinklers Failed to Operate
Public assembly	19%
Educational	11%
Health care or correctional	7%
Residential	3%
Stores or office	10%
Manufacturing	7%
Storage	15%
All properties*	9%

*Includes some properties not listed separately above.

Note: These are percentages of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Percents are used without numbers because the fraction of data reported directly in Version 5.0, not converted from Version 4.1, is still small and may not be representative. Figures exclude confined fires and fires coded as too small to test operationality.

Source: NFIRS and NFPA survey

Table 2. (Continued)

**Automatic Extinguishing System Operationality in Structure Fires
When Fire Was Large Enough to Activate System
After Recoding of Errors Based on Reasons for Ineffectiveness or Failure to Operate,
by Property Use, 1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments (Continued)**

B. Sprinklers Only

Property Use	Percent Where Sprinklers Failed to Operate
Public assembly	10%
Educational	7%
Health care or correctional	5%
Residential	3%
One and two-family dwelling	6%
Apartment	2%
Hotel or motel	4%
Store or office	9%
Manufacturing	7%
Storage	14%
Cold-storage or other warehouse	11%
All properties*	7%

*Includes some properties not listed separately above.

Note: These are percentages of fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percents are used without numbers because the fraction of data reported directly in Version 5.0, not converted from Version 4.1, is still small and may not be representative. Figures exclude confined fires and fires coded as too small to test operationality.

Source: NFIRS and NFPA survey

Table 3.
Reasons Why Automatic Extinguishing Systems Failed to Operate
When Present in Area of Fire Origin and Fire Was Large Enough to Activate System,
After Recoding of Errors, by Property Use
1999-2002 Structure Fires (Excluding Confined Fires) Reported in NFIRS Version 5.0 to U.S. Fire Departments

A. All Automatic Extinguishing Systems

Property Use	System shut off	Manual intervention defeated system	Lack of maintenance	Wrong type of system	System component damaged	Total
Public assembly	17%	5%	49%	17%	12%	100%
Educational	41%	59%	0%	0%	0%	100%
Health care or correctional	50%	50%	0%	0%	0%	100%
Residential	61%	23%	8%	8%	0%	100%
Store or office	33%	25%	25%	13%	4%	100%
Manufacturing	71%	15%	12%	3%	0%	100%
Storage	88%	6%	6%	0%	0%	100%
All properties*	52%	16%	21%	7%	3%	100%

*Includes some properties not listed separately above.

Note: These are percentages of fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percents are used without numbers because the fraction of data reported directly in Version 5.0, not converted from Version 4.1, is still small and may not be representative. Figures exclude confined fires and fires coded as too small to test operationality.

Source: NFIRS and NFPA survey

Table 3. (Continued)
Reasons Why Automatic Extinguishing Systems Failed to Operate
When Present in Area of Fire Origin and Fire Was Large Enough to Activate System,
After Recoding of Errors, by Property Use
1999-2002 Structure Fires (Excluding Confined Fires) Reported in NFIRS Version 5.0 to U.S. Fire Departments

B. Sprinklers Only

Property Use	System shut off	Manual intervention defeated system	Lack of maintenance	Wrong type of system	System component damaged	Total
Public assembly	23%	0%	39%	13%	25%	100%
Educational	68%	32%	0%	0%	0%	100%
Health care or correctional	35%	65%	0%	0%	0%	100%
Residential	80%	20%	0%	0%	0%	100%
One- or two-family dwelling	0%	100%	0%	0%	0%	100%
Apartment	81%	19%	0%	0%	0%	100%
Hotel or motel	100%	0%	0%	0%	0%	100%
Store or office	35%	30%	15%	16%	5%	100%
Manufacturing	76%	12%	12%	0%	0%	100%
Storage	79%	7%	7%	8%	0%	100%
Cold storage or other warehouse	89%	11%	0%	0%	0%	100%
All properties*	65%	16%	11%	5%	3%	100%

*Includes some properties not listed separately above.

Note: These are percentages of fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percents are used without numbers because the fraction of data reported directly in Version 5.0, not converted from Version 4.1, is still small and may not be representative. Figures exclude confined fires and fires coded as too small to test operability.

Source: NFIRS and NFPA survey

Table 4.

**Automatic Extinguishing System Performance, by Property Use
1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments
After Recoding Based on Reasons for Failure or Ineffectiveness**

A. All Automatic Extinguishing Systems

Fixed Property Use	Operated and Effective	Operated and Not Effective	Fire Too Small to Activate System	Failed to Operate
Public assembly	26%	11%	54%	9%
Educational	20%	1%	77%	3%
Health care or correctional	23%	1%	75%	2%
Residential	39%	3%	57%	1%
Stores and offices	33%	3%	61%	4%
Manufacturing	48%	5%	43%	4%
Storage	44%	8%	39%	9%
All properties*	36%	4%	56%	4%

*Includes some properties not separately listed above.

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Percentages are estimated from structure fires where sprinklers were present in area of fire origin and operation was known.

Source: NFIRS and NFPA survey.

Table 4. (Continued)

**Automatic Extinguishing System Performance, by Property Use
1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments
After Recoding Based on Reasons for Failure or Ineffectiveness**

B. Sprinklers Only

Fixed Property Use	Operated and Effective	Operated and Not Effective	Fire Too Small to Activate System	Failed to Operate
Public assembly	34%	4%	58%	4%
Educational	22%	0%	76%	2%
Health care or correctional	24%	0%	74%	1%
Residential	40%	1%	58%	1%
One- or two-family dwelling	46%	0%	51%	3%
Apartment	47%	1%	51%	1%
Hotel or motel	31%	2%	66%	1%
Stores and offices	35%	1%	61%	3%
Manufacturing	48%	3%	45%	4%
Storage	47%	5%	38%	9%
Cold storage or other warehouse	56%	2%	34%	8%
All properties*	38%	2%	57%	3%

*Includes some properties not separately listed above.

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Percentages are estimated from structure fires where sprinklers were present in area of fire origin and operation was known.

Source: NFIRS and NFPA survey.

Table 4. (Continued)

**Automatic Extinguishing System Performance, by Property Use
1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments
After Recoding Based on Reasons for Failure or Ineffectiveness**

C. Percentage Effective Among Fires Where Systems Operated

Fixed Property Use	All Automatic Extinguishing Systems	Sprinklers Only
Public assembly	72%	90%
Educational	96%	98%
Health care or correctional	98%	99%
Residential	93%	97%
One- or two-family dwelling	NC	100%
Apartment	NC	98%
Hotel or motel	NC	94%
Store or office	92%	97%
Manufacturing	90%	95%
Storage	85%	90%
Cold storage or other warehouse	NC	96%
All properties*	89%	96%

NC – Not calculated for all automatic extinguishing systems.

*Includes some properties not separately listed above.

Note: These are national estimates of fires reported to U.S. municipal fire departments and exclude fires reported only to Federal or state agencies or industrial fire brigades. Percentages are estimated from structure fires where sprinklers were present in area of fire origin and operation was known.

Source: NFIRS and NFPA survey.

Table 5.

**Reasons Why Automatic Extinguishing Systems Are Deemed Ineffective When Present in Area of Fire Origin and Fire Was Large enough to Activate System, After Recoding of Errors, by Property Use
1999-2002 Structure Fires (Excluding Confirmed Fires) Reported in NFIRS Version 5.0 to U.S. Fire Departments**

A. All Automatic Extinguishing Systems

Property Use	Agent did not reach fire	Not enough agent released	Inappropriate system for type of fire	System component damaged	Manual intervention defeated system	Total
Public assembly	46%	34%	11%	0%	9%	100%
Educational	0%	100%	0%	0%	0%	100%
Health care or correctional	100%	0%	0%	0%	0%	100%
Residential	78%	22%	0%	0%	0%	100%
Store or office	36%	51%	13%	0%	0%	100%
Manufacturing	55%	26%	9%	10%	0%	100%
Storage	21%	39%	41%	0%	0%	100%
All properties*	50%	32%	11%	4%	3%	100%

*Includes some properties not listed separately above.

Note: These are percentages of fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percents are used without numbers because the fraction of data reported directly in Version 5.0, not converted from Version 4.1, system is still small and may not be representative. Excludes confined fires and fires where system was present but fire coded as fire too small to test operationality.

Source: NFIRS and NFPA survey

Table 5. (Continued)

**Reasons Why Automatic Extinguishing Systems Are Deemed Ineffective When Present in Area of Fire Origin and Fire Was Large enough to Activate system, After Recoding of Errors, by Property Use
1999-2002 Structure Fires (Excluding Confirmed Fires) Reported in NFIRS Version 5.0 to U.S. Fire Departments**

B. Sprinklers Only

Property Use	Agent did not reach fire	Not enough agent released	Inappropriate system for type of fire	System component damaged	Manual intervention defeated system	Total
Public assembly	19%	65%	0%	0%	16%	100%
Educational	0%	100%	0%	0%	0%	100%
Health care or correctional	100%	0%	0%	0%	0%	100%
Residential	77%	23%	0%	0%	0%	100%
One- or two-family dwelling	NA	NA	NA	NA	NA	NA
Apartment	81%	19%	0%	0%	0%	100%
Hotel or motel	73%	27%	0%	0%	0%	100%
Store or office	63%	37%	0%	0%	0%	100%
Manufacturing	57%	21%	10%	12%	0%	100%
Storage	27%	50%	23%	0%	0%	100%
Cold storage or other warehouse	0%	100%	0%	0%	0%	100%
All properties*	55%	31%	7%	5%	2%	100%

NA – Not applicable because no reported cases of ineffective performance.

*Includes some properties not listed separately above.

Note: These are percentages of fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percents are used without numbers because the fraction of data reported directly in Version 5.0, not converted from Version 4.1, system is still small and may not be representative. Excludes confined fires and fires where system was present but fire coded as fire too small to test operability.

Source: NFIRS and NFPA survey

Table 6.

**Number of Wet-Pipe Sprinklers Operating in
Structure Fires Where Sprinklers Were Present and Operated
1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments**

**A. Percentage of Fires with Indicated Number of Sprinklers Operating,
for Cases of Effective vs. Ineffective Performance**

Number of Sprinklers Operating	Operated and Was Effective	Operated and Was Not Effective
1	67%	50%
2 or fewer	83%	66%
3 or fewer	89%	76%
4 or fewer	92%	83%
5 or fewer	94%	87%
6 or fewer	95%	88%
7 or fewer	96%	88%
8 or fewer	96%	89%
9 or fewer	97%	90%
10 or fewer	98%	92%

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Wet-pipe systems outnumbered dry-pipe systems by 7-to-1. Wet-pipe systems outnumbered "other type sprinkler" systems by nearly 30-to-1. However, 38% of the incidents had type of sprinkler system unreported. Percentages are based on fires where sprinklers were reported present and operating and there was reported information on number of sprinklers operating.

Source: NFIRS and NFPA survey.

Table 6. (Continued)

**Number of Wet-Pipe Sprinklers Operating in
Structure Fires Where Sprinklers Were Present and Operated,
1999-2002 Structure Fires (Excluding Confined Fires)
Reported in NFIRS Version 5.0 to U.S. Fire Departments**

**B. Percent of Fires Where Performance Was Effective,
by Number of Sprinklers Operating**

Number of Sprinklers Operating	Percent of Fires Where Sprinklers Were Effective
1	95%
2	94%
3	91%
4 to 10	89%
More than 10	81%
Total	94%

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Wet-pipe systems outnumbered dry-pipe systems by 7-to-1. Wet-pipe systems outnumbered "other type sprinkler" systems by nearly 30-to-1. However, 38% of the incidents had type of sprinkler system unreported. Percentages are based on fires where sprinklers were reported present and operating and there was reported information on number of sprinklers operating.

Source: NFIRS and NFPA survey.