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THE RELIABILITY OF SPRINKLER SYSTEMS (REVISITED)

By Richard Schulte

The issue of the reliability of sprinkler protection has been the topic of heated debate in the fire protection field for more than a decade. In 2005, a paper on the issue developed by William Koffel, Koffel Associates Inc., concluded that sprinkler systems may fail to perform effectively in as many as 1 in 6 fires large enough activate sprinkler protection. To be fair, the original paper developed by Koffel concluded that the average failure rate of sprinkler systems was likely in the range of between 10 and 16 percent, however, the statistic which was cited by proponents of a concept referred to as "balanced fire protection" based upon Koffel's work was the "worst-case" scenario, a 16 percent (1 in 6) failure rate.

Since 2005, the National Fire Protection Association (NFPA) has issued several reports on the reliability of sprinkler systems, including a report issued in February 2010. The latest report on the subject issued by the NFPA is dated September 2010. This report titled "*U.S. Experience with Sprinklers and Other Automatic Fire Extinguishing Equipment*" authored by John R. Hall, Jr. includes the following excerpts:

"*Sprinklers operated in 91% of all reported structure fires large enough to activate sprinklers, excluding buildings under construction and buildings without sprinklers in the fire area.* When sprinklers operate, they are effective 96% of the time, resulting in a combined performance of operating effectively in 87% of all reported fires where sprinklers were present in the fire area and fire was large enough to activate them.*"

"*When sprinklers operate, they are effective 96% of the time, resulting in a combined performance of operating effectively in 87% of all reported fires where sprinklers were present in the fire area and fire was large enough to activate them.*"

"** Because nearly all fires reported as confined fires are reported without sprinkler performance details or as fires too small to activate operating equipment, confined fires are not included in any analysis involving reliability or effectiveness of automatic extinguishing equipment. . .*"

"*These most current statistics exclude buildings under construction and cases of failure or ineffectiveness because of a lack of sprinklers in the fire area and after some recoding between failure and ineffectiveness based on reasons given.*"

"*When sprinklers fail to operate, the reason most often given (64% of failures) was shutoff of the system before fire began, as may occur in the course of routine inspection maintenance.*"

"*When people are fatally injured in spite of the operation of wet-pipe sprinklers, the victims often had special vulnerabilities that are less often found with fatal victims of home fires in general.*"

"*65% of fatal victims in home fires with wet-pipe sprinkler operation were age 65 or older, compared to 28% of fatal home fire victims when no automatic extinguishing equipment was present; . . .*"

"*The death rate per fire in sprinklered homes is lower by 83%.*"

"*Statistics are based on 2004-2008 U.S. reported fires excluding buildings under construction and properties with no sprinklers in fire area. . .*"

"*The death rate per fire in sprinklered homes is lower by 83%.*"

"*Wet pipe sprinklers operated and were effective in 88% of non-confined fires vs. 74% for dry pipe sprinklers.*"

"*In 2004-2008 fires where sprinklers operated, they were effective in 96% of the cases.*"

"*When wet pipe sprinklers operated, 89% of reported fires involved only 1 or 2 sprinklers.*"

"*The fire statistics in this analysis 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. These estimates are projections based on the detailed information collected in Version 5.0 of the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS 5.0) and the NFPA's annual fire department experience survey.*"

"*NFIRS incident type codes for structure fires include six types of confined fires - confined to chimney or flue, fuel burner or boiler, cooking vessel, incinerator, commercial compactor, or trash. Reporting of most details of* [is] *optional for confined fires. Therefore, the standard NFPA analysis practice of proportional allocation of unknowns in all fields produces highly variable results for confined fires, which have much larger unknown shares. It is difficult to imagine a fire small enough to be coded as a confined fire but still large enough to activate operational automatic extinguishing equipment. Very few confined fires have equipment performance details coded and are not coded as fire too small to activate equipment. Because of the large share of reported fires that are confined and the large share of confined fires with no reported details, the few confined fires coded as operated, failed, or ineffective have a disproportionate effect on estimates of reliability and effectiveness. In all likelihood, most of these fires are miscoded non-confined fires or miscoded fires too small to activate equipment. Therefore confined fires are not included in estimates of reliability and ineffectiveness but are included in analyses of presence and type of equipment.*"

"*Because of the large share of reported fires that are confined and the large share of confined fires with no reported details, the few confined fires coded as operated, failed, or ineffective have a disproportionate effect on estimates of reliability and effectiveness.*"

"*In 2004-2008, sprinklers were reported present in only 9% of reported structure fires and only 11% reported any type of automatic extinguishing equipment present, including but not limited to sprinklers.*"

"*In 2004-2008, sprinklers were reported present in only 9% of reported structure fires . . .*"

"*In 2004-2008, sprinklers were reported in only 6% of fires in homes (including apartments). Clearly, there is great potential for expanded installation.*"

"*Sprinklers are installed in 13.0% of housing units in buildings that were constructed no more than four years ago.*"

"*To underscore the principal finding, more than 1 million single family detached dwellings now have fire sprinklers.*"

"*NFPA 101®, Life Safety Code; NFPA 1, Fire Code; and NFPA 5000®, Building Construction and Safety Code, have required sprinklers in all new one- and two-family homes, all nursing homes, and many nightclubs since the 2006 editions.*"

"*When sprinklers were present, the percentages of fires too small to activate operational sprinklers, based on reported non-confined structure fires in any property use, were as follows:*

- *49% for all sprinklers,*
- *49% for wet pipe sprinklers, and*
- *53% for dry pipe sprinklers.*"

"* *Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, burner or boiler, commercial compactor, incinerator, or trash.*"

"*Here is a summary of other effective operation percentages.*

- *88% for wet pipe sprinklers, and*
- *74% for dry pipe sprinklers.*"

"*A disadvantage of measuring automatic extinguishing equipment effectiveness by judgments made in incident reports is the ambiguity and subjectivity of the criterion of "effective," which has never been precisely defined, let alone supported by an operational assessment protocol that could be executed consistently by different people.*"

"***Roughly two-thirds (64%) of sprinkler failures in non-confined fires occurred because the system was shut off.***"

"*For all structures combined, 73% have flame damage confined to room of origin when there is no automatic extinguishing equipment present. This rises to 95% of fires with flame damage confined to room of origin when any type of sprinkler is present.*"

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"***Dry pipe sprinklers tend to have more sprinklers operating than wet pipe sprinklers.*** *Table 7A shows the number of sprinklers operating by type of sprinkler system. Five or fewer heads* [sprinklers] *operated in 97% of the wet pipe system activations and 90% of the dry pipe system activations.*"

"***Wet pipe sprinkler systems tend to have more sprinklers operating in fires in manufacturing facilities or warehouses than in other properties.***"

"*When more than 1-2 sprinklers have to operate, this may be taken as an indication of less than ideal performance. . .Furthermore, most sprinkler installations are designed for control, not extinguishment, and anticipate that multiple sprinklers will be needed for control in some fire scenarios.*"

"*An exception is systems designed to NFPA 13D (the home sprinkler standard), for which maintenance, inspection, and testing requirements are much fewer, reflecting the greater inherent reliability of the simpler design, and are included in the NFPA 13D standard.*"

"*NFPA standards for specific occupancies or for fire service operations provide guidance for fire protection and firefighting in a sprinklered building. These rules address the best use of fire suppression equipment in combination with fire sprinklers and the need to confirm that fire conditions no longer pose a threat before shutting off sprinklers.*"

"*The NFPA compilation includes several incidents involving partial coverage by any definition but also several incidents where coverage was described as complete but was not provided for areas of fire origin or of early fire growth in concealed or void spaces, on balconies or other outside locations, or above sprinklers in manufacturing or storage facilities.*"

"*For properties other than homes, deaths tend to be extremely rare, with or without sprinklers.*"

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"*Warehouses illustrate the statistical problem of analyzing impact when there are very few fatal fires. Total fire deaths in sprinklered warehouses in 2004-2008 are estimated from projections based on only two fatal incidents. . .*"

"*The factors that make fatal injury possible even when sprinklers are present and operate would include the following, including those shown in Table 10:*

1. *Victims whose actions or lack of action add to their risk by prolonging their exposure to fire conditions. . .*

2. *Victims of fires that are beyond the design limits of the system, such as fires that were* (a) *so close that the victim is deemed "intimate with ignition" . . .*(b) *very fast, such as explosions or flash fires; or* (c) *outside the sprinkler-protected area . . .*

3. *Victims who are or may be unusually vulnerable to fire effects . . .or (b) people who are in poor health before fire begins.*"

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"*According to a 15-year study done in Scottsdale, Arizona, on average, a fire sprinkler will use 25 gallons of water per minute to control a home fire as compared to the estimated 250 gallons used by firefighters.*"

"*In surveys, many people say they do not want sprinklers. The question is why.*"

"*A 2008 study, conducted by Newport Partners under sponsorship of the Fire Protection Research Foundation, developed comprehensive and all-inclusive cost estimates for 30 diverse house plans in 10 communities.*[9] *Cost per sprinklered square foot ranged from $0.38 to $3.66, with an average (mean) of $1.61 and a median of $1.42.*"

"[9] *Newport Partners, Home Fire Sprinkler Cost Assessment – Final Report, Fire Protection Research Foundation, Quincy, MA, September 2008, pp.* iv *and 6.*"

"*Many people are not aware how much the cost of sprinkler systems and the cost of installing them have been reduced in recent years as a result of continued innovation in the industry.*"

"*Sprinkler systems are so effective that it can be tempting to overstate just how effective they are.*"

"*It is important for all concerned parties to* (a) *distinguish between human and mechanical problems because they require different strategies;* (b) *include both as concerns to be addressed when deciding when and how to install, maintain, and rely on sprinklers and other automatic extinguishing systems;* © *strive to use performance analysis in assessing any other element of fire protection; and* (d) *remember that the different elements of fire protection support and reinforce one another and so must always be designed and considered as a system.*"

Analysis and Commentary

. . .there is no question in my mind that the latest NFPA report represents an unbiased representation of the data available to the NFPA.

Previous NFPA studies on the subject of the reliability (or effectiveness) of sprinkler protection have supported the viewpoint that the reliability of sprinkler protection is higher than indicated in the September 2010 study. This version of the study indicates that the reliability (or effectiveness) of sprinkler protection is higher than 84 percent, but less than supporters of reductions in passive fire protection features, commonly referred to as "sprinkler trade-offs", have contended. Although it is my personal opinion that the reliability of sprinkler protection is higher than indicated in the September 2010 NFPA version of the study (based upon my more than 3 decades of experience with sprinkler protection), there is no question in my mind that the latest NFPA report represents an unbiased representation of the data available to the NFPA.

Even though NFPA's data and conclusions are not biased, other smaller studies of sprinkler system reliability appear to demonstrate that sprinkler system reliability is close to 100 percent. These studies include the experience with residential sprinkler protection in two jurisdictions, Scottsdale, Arizona and Prince George's County, Maryland, and the NIST investigation of the collapse of the World Trade Center towers. These studies, taken together with anecdotal experience related by various fire service representatives from around the country, raise doubts in my mind as to whether or not the NFPA's conclusions provide a totally accurate picture.

Rather than argue over whether the reliability statistic for sprinkler protection is 91 percent, 87 percent or 84 percent, however, it is my opinion that even 91 percent is not an acceptable level of reliability for sprinkler protection. Given that sprinkler protection provides the primary means of providing fire protection for the occupants in many large buildings, there is no excuse for the level of reliability or effective operation being anything but close to 100 percent.

In the modern world, we have perfected the reliability of both aircraft and automobiles. If we can build and maintain aircraft and automobiles to be nearly 100 percent reliable, there seems to be no reason why we can't build and maintain sprinkler systems to be similarly as reliable. After all, in America, we have close to 250,000 paid professional fire fighters and another 750,000 volunteer fire fighter who are responsible for the fire safety of the public and who should have an interest in whether or not sprinkler systems are maintained in an operable condition.

The budget problems of the Federal government, state governments and local governments are well known. For the last two years, the Federal government's economic stimulus program has insulated state and local government from the effects of the economic downturn, however, the funding of the Federal stimulus program is set to end in a few months. Once the finances of state and local governments are no longer being "shored up" by funding from the stimulus program, dramatic cuts in state and local budgets are almost sure to follow. From a fire protection standpoint, what this means is cuts in fire department budgets.

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While many in the fire service feel that local fire departments are understaffed at present, reductions in municipal fire department budgets will exacerbate this problem even further. It seems reasonable to conclude that the only way to maintain the current level of public fire protection is through an increased use of private fire protection, *i.e.*, sprinkler protection.

While sprinkler protection only addresses the structural fire problem, sprinkler protection has shown itself to be an effective substitute for both fire fighting personnel and equipment for structure fires since the mid-1970's. Unfortunately, as illustrated by the statistic that only 9 percent of structure fires occur in sprinklered buildings, most of existing building stock in the U.S. is not provided with sprinkler protection. That will have to change in an era of limited government resources.

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The good part about the increased use of sprinkler protection, aside from the fact that sprinkler protection is an effective substitute for public fire protection resources, is that the almost universal use of sprinkler protection can practically eliminate fire fatalities and cause a substantial reduction in the number of fire injuries. Safer buildings, fewer fire fatalities and fire injuries and a reduced need for public fire protection resources-sounds like an ideal solution for a problem that has plagued civilization for centuries.

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That doesn't mean that we will be able to do without fire fighters. (Fire fighters will still be needed to address vehicle fires, wildland fires and make sure that sprinkler protection is being properly maintained.) It just means that fire fighting will be safer and that we will be providing better fire protection for the public.

Of course, if the reliability/effectiveness of sprinkler protection increases to close to 100 percent, we won't have to discuss the issue of "balanced fire protection" anymore. Think of all the time saved at code development hearings. That time can be put to good use making sure that existing sprinkler protection provided is being properly maintained.

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Editor's Note: Richard Schulte is a 1976 graduate of the fire protection and safety engineering program at the Illinois Institute of Technology (IIT) in Chicago. Schulte worked as the fire protection engineer for the San Jose (California) Fire Department from 1980-1982. Schulte was named as one of ENR's "Top 25 Newsmakers of 2004" by Engineering News-Record for his work on critiquing the National Institute of Standards and Technology (NIST) investigation into the collapse of the World Trade Center towers on 9/11.