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THE RELIABILITY OF SPRINKLER SYSTEMS: THE LATEST STATISTICS (2010)

By Richard Schulte

The reliability of sprinkler systems as been an issue which has been debated for close to a decade. A trade association of passive fire protection manufacturers, the Alliance for Fire and Smoke Containment and Control (AFSCC), coined the term "balanced fire protection" as a means to overturn reductions in passive fire protection in buildings protected throughout by a sprinkler system, commonly referred to as "sprinkler trade-offs", permitted in the 2000 edition of the International Building Code.

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The term "balanced fire protection" as defined by the AFSCC is a essentially "a little bit of this and a little bit of that". In other words, in order for buildings to be "safe", passive fire protection is needed as a backup to active fire protection (sprinkler protection) just in case the active fire protection system fails to "work" properly. Of course, in order to make this case, the reliability of sprinkler protection must be questioned and that is the approach that the AFSCC utilized to make the case for "balanced fire protection".

Is sprinkler protection one hundred percent reliable? Of course not, but the "sprinkler trade-offs" included in the 2000 edition of the International Building Code were based upon the assumption that sprinkler protection is sufficiently reliable to justify reduction in passive fire protection requirements permitted. Ten years ago, the accepted reliability statistic for sprinkler systems was 95 to 96 percent, meaning that the sprinkler systems performed effectively 95 to 96 percent of the time.

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In order to challenge the assumption that sprinkler systems successfully control fires (large enough to activate sprinklers) roughly 95 to 96 percent of the time, the AFSCC retained the services of a former president of the Society of Fire Protection Engineers (SFPE), William Koffel of Koffel & Associates, to dispute the assumed sprinkler reliability statistic. Utilizing data from a report on sprinkler operations published by the National Fire Protection Association (NFPA), Koffel computed the sprinkler system reliability statistic to actually be between 84 percent and 90 percent.

While Koffel reported the reliability of sprinkler system as a range, the AFSCC only utilized the low end of the range to conclude that sprinkler systems fail 1 in every 6 fires large enough to activate sprinklers (and Koffel did not publicly correct the AFSCC's assertions regarding the failure rate of sprinkler system). With the AFSCC's consultants, in particular, Vickie Lovell and Rick Thornberry, continuously pounding away at the reliability of sprinkler systems, many in the fire protection field began to question the reliability of sprinkler systems.

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With the publication of new data on the reliability of sprinkler systems contained in a NFPA report dated September 2005, it became obvious that the AFSCC had overstated the failure rate of sprinkler systems. Unfortunately, many in the field didn't see the September 2005 NFPA report and the 1 in 6 failure rate statistic almost became legendary.

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Since September 2005, the NFPA has published several reports on the reliability of sprinkler systems. The latest NFPA report on sprinkler system reliability titled "*U.S. Experience with Sprinklers and Other Automatic Fire Extinguishing Equipment*" written by John R. Hall, Jr. of NFPA Fire Analysis and Research Division is dated February 2010. The following are excerpts from this report:

> "When sprinklers are present in the fire area, they operate in 93% of all reported structure fires large enough to activate sprinklers, excluding buildings under construction. When they operate, they are effective 97% of the time, resulting in a combined performance of operating effectively in 91% of reported fires where sprinklers were present in the fire area and fire was large enough to activate sprinklers." (Abstract)

"In homes (including apartments), wet-pipe sprinklers operated effectively 96% of the time." (Abstract)

"When wet-pipe sprinklers are present in structures that are not under construction and excluding cases of failure or ineffectiveness because of a lack of sprinklers in the fire area, the fire death rate per 1,000 reported home structure fires is lower by 83% and the rate of property damage per reported structure fire is lower by 40-70% for most property uses." (Page *I*)

"In homes (including apartments), wet-pipe sprinklers operated effectively 96% of the time."

"When sprinklers fail to operate, the reason most often given (53% of failures) was shutoff of the system before fire began, as may occur in the course of routine inspection [and] maintenance. Other leading reasons were inappropriate system for the type of fire (20%), lack of maintenance (15%), and manual intervention that defeated the system (9%). Only 2% of sprinkler failures were attributed to component damage." (Page *I*)

"Wet pipe sprinklers operated and were effective in 92% of fires vs. 79% for dry pipe sprinklers." (Page *vii*)

"Wet pipe sprinklers operated and were effective in 92% of fires vs. 79% for dry pipe sprinklers."

"Usually only 1 or 2 sprinklers are required to control the fire.

- When wet pipe sprinklers operated, 89% of reported fires involved only 1 or 2 sprinklers.
- For dry pipe sprinklers, 74% involved only 1 or 2 sprinklers." (Page *viii*)

"Because sprinkler systems are so demonstrably effective, they can make a major contribution to fire protection in any property. 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 dwellings, all nursing homes, and many nightclubs since the 2006 editions. The 2009 edition of the *International Residential Code*, also added requirements for sprinklers in one- and two-family dwellings, effective January 2011." (Page 4)

"The major property class with the largest share for dry pipe sprinklers was storage, where dry pipe sprinklers accounted for 20% of the systems cited." (Page 7)

"In order to estimate the reliability and effectiveness of any type of automatic extinguishing equipment, the database must first be edited to remove fires, buildings, and systems where operation cannot be expected, such as small fires, buildings under construction, and partial installations." (Page 11)

"**Sprinklers in the area of fire failed to operate in only 7% of reported structure fires large enough to activate sprinklers.** . . . The other estimated failure rates corresponding to percentage operating rates shown in Table 3A are:

- 5% for wet pipe sprinklers,
- 17% for dry pipe sprinklers, . . ." (Pages 11 and 12)

"For major property classes and sprinklers, the estimated failure rates range from a low of 4% for residential properties, public assembly properties and stores and offices to a high of 32% for educational properties and 29% for storage properties. The estimated failure rates for wet pipe sprinklers specifically were 25% for educational properties and 16% for storage properties." (Page 12)

"Wet pipe sprinklers are both much more reliable than dry pipe sprinklers (95% vs. 83%) and slightly more effective when they operate (98% vs. 95%), resulting in a much higher percentage of effective operation (92% vs. 79%)." (Page 12)

"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." (Page 12)

"For major property classes and sprinklers, the estimated failure rates range from a low of 4% for residential properties, public assembly properties and stores and offices to a high of 32% for educational properties and 29% for storage properties. The estimated failure rates for wet pipe sprinklers specifically were 25% for educational properties and 16% for storage properties."

"For all types of sprinklers combined:

- 53% of failures to operate were attributed to the equipment being shut off,
- 20% were because the equipment was inappropriate for the type of fire,
- 15% were because of lack of maintenance,
- 9% were because manual intervention defeated the equipment, and
- 2% were because a component was damaged." (Page 13)

"Because the design of dry pipe sprinklers assures a delayed release of water, it is not surprising that when such systems are ineffective, an insufficiency of water is usually involved." (Page 14)

"Therefore, the benefits of sprinklers will tend to come in the following scenarios:

- A fire that would otherwise have spread beyond the room of fire origin will be confined to the room of origin, resulting in a smaller fire-damaged area and less property damage.

- A fire that would otherwise have grown larger than the design fire area in a room larger than that area will be confined to the design fire area, resulting in a smaller fire-damaged area and less property damage.

- A fire will be confined to an area smaller than the room or the design fire area, even though that degree of success goes beyond the performance assured by the design, resulting in a smaller fire-damaged area and less property damage." (Page 15)

"For all structures combined, 74% 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." (Page 15)

". . . Five or fewer heads [sprinklers] operated in 97% of the wet pipe system activations and 89% of the dry pipe system activations."

"**Dry pipe sprinklers tend to have more sprinklers operating than wet pipe sprinklers.** . . . Five or fewer heads operated in 97% of the wet pipe system activations and 89% of the dry pipe system activations." (Page 15)

"Dry-pipe systems are much more likely to open more than one sprinkler than wet pipe systems (39% vs. 23% of fires). The likely reason is the designed 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." (Page 15)

"**Wet pipe sprinkler systems tend to have more sprinklers operating in fires in manufacturing facilities or warehouses than in other properties.**" (Page 16)

"In warehouses or manufacturing facilities respectively, 69-70% of the fires in properties where wet pipe sprinklers operated had two or fewer sprinklers operating, which means 30-31% of the fires in properties had at least three sprinklers operating. Similarly, 89-90% had five or fewer sprinklers operating, which means 10-11% had at least six sprinklers operating. By contrast, in public assembly properties and stores and offices where wet pipe sprinklers operated, 87-90% of fires in properties had two or fewer sprinklers operating, which means only 10-13% of fires in properties had at least three sprinklers operating. Similarly, 95-96% had five or fewer sprinklers operating, which means only 4-5% had at least six sprinklers operating." (Page 16)

"When more than 1-2 sprinklers have to operate, this may be taken as an indication of less than ideal performance. . . .At the same time, the number of sprinklers operating should not be used as an independent indicator of effectiveness because sprinklers are deemed effective in most fires where sprinklers operate, no matter how many sprinklers operate. Furthermore, most sprinkler installations are designed for control, not extinguishment, and anticipate that multiple sprinklers will be needed for control in some fire scenarios." (Page 17)

"**For 2003-2007 home fires, the death rate per 100 fires was 83% lower with wet pipe sprinklers than with no automatic extinguishing equipment.**" (Page 39)

"Only the statistics for homes (including apartments) are based on enough fatal fires, both with and without sprinklers, for reasonable confidence in the results. Even the home fire statistics are volatile because of the influence of confined fires, where details on sprinkler presence and performance are not required and rarely provided." (Page 39)

"For 2003-2007 home fires, the death rate per 100 fires was 83% lower with wet pipe sprinklers than with no automatic extinguishing equipment."

"Manufacturing facilities show a small reduction in an already low death rate, while warehouses show no reduction. Warehouses illustrate the statistical problem of analyzing impact when there are very few fatal fires. Total fire deaths in sprinklered warehouses in 2003-2007 are estimated from projections based on only four fatal incidents." (Page 39)

"**For most property uses, the property damage rate per reported structure fire is 40-70% lower than in properties with no automatic extinguishing equipment when wet pipe sprinklers are present in structures that are not under construction, after excluding cases of failure or ineffectiveness because of a lack of sprinklers in the fire area.**" (Page 40)

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"A fire with a sufficient number of different points of origin can overwhelm any sprinkler system. This could also be an exception to the life-saving effectiveness statement, although it has not been found to be the deciding factor in any multiple-death fire to date. It has been the deciding factor for at least one large-loss fire. Multiple points of origin can occur deliberately in an arson fire, but they can occur unintentionally or naturally, as when an outside fire spreads to numerous entry points in and on a building." (Page 42)

"A third myth has to do with the affordability of sprinklers. . . . Sprinklers are not inexpensive, although their effectiveness, documented earlier, means most people will find them cost-effective. "

"Much of the resistance to wider use of sprinklers stems from a cluster of concerns that are not so much issues as myths. Most Americans have had little contact with sprinkler systems outside of their portrayal in movies and television shows, where sprinklers all too often are portrayed inaccurately. For instance, activation by common heat sources, activation of all sprinklers if any one is activated, even drowning or swimming in the water released by sprinklers, all have been portrayed in film versions of sprinkler activation." (Page 47)

"Unintentional release of water in a non-fire activation of a sprinkler appears to be less likely and much less damaging, according to the best available evidence, than is unintentional water release involving other parts of a building's plumbing and water supply, which tend to be both more frequent and more costly per incident." (Page 48)

"A third myth has to do with the affordability of sprinklers. Sprinklers are not inexpensive, although their effectiveness, documented earlier, means most people will find them cost-effective. This often can be incorporated into reduced insurance costs and incentives applied by community planners in new developments." (Page 50)

"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. When people say they are not interested in sprinklers for cost reasons, they may well be reacting to an inflated notion of those costs." (Page 51)

"Fire sprinklers are highly reliable and effective elements of total system designs for fire protection in buildings. They save lives and property, producing large reductions in the number of deaths per thousand fires, in average direct property damage per fire, and especially in the likelihood of a fire with large loss of life or large property loss." (Page 53)

"Sprinkler systems are so effective that it can be tempting to overstate just how effective they are. For example, some sprinkler proponents have focused too narrowly on the reliability of the components of the sprinkler system itself. If this were the only concern in sprinkler performance, then there would be little reason for concern at all, but human error is a relevant problem." (Page 53)

"On the other hand, human error is not a problem unique to sprinklers. In fact, all forms of active and passive fire protection tend to show more problems with human error than with intrinsic mechanical or electrical reliability." (Page 53)

"Because sprinkler systems are so demonstrably effective, they can make a major contribution to fire protection in any property. 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 dwellings, all nursing homes, and many nightclubs since the 2006 editions. The 2009 edition of the *International Residential Code* also added requirements for sprinklers in one- or two-family dwellings, effective January 2011. This protection can be expected to increase in areas that adopt and follow these revised codes." (Page 54)

"The statistics in this analysis are estimates derived from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual survey of U.S. fire departments. NFIRS is a voluntary system by which participating fire departments report detailed factors about the fires to which they respond. Roughly two-thirds of U.S. fire departments participate, although not all of these departments provide data every year. Fires reported to federal or state fire departments or industrial fire brigades are not included in these estimates." (Page 55)

"Each year, NFPA conducts an annual survey of fire departments which enables us to capture a summary of fire department experience on a larger scale. Surveys are sent to all municipal departments protecting populations of 50,000 or more and a random sample, stratified by community size, of the smaller departments. Typically, a total of roughly 3,000 surveys are returned, representing about one of every ten U.S. municipal fire departments and about one third of the U.S. population." (Page 55)

"As noted, NFIRS is a voluntary system. Different states and jurisdictions have different reporting requirements and practices. Participation rates in NFIRS are not necessarily uniform across regions and community sizes, both factors correlated with frequency and severity of fires. This means NFIRS may be susceptible to systematic biases. No one at present can quantify the size of these deviations from the ideal, representative sample, so no one can say with confidence that they are or are not serious problems. But there is enough reason for concern so that a second database -- the NFPA survey -- is needed to project NFIRS to national estimates and to project different parts of NFIRS separately. This multiple calibration approach makes use of the annual NFPA survey where its statistical design advantages are strongest." (Page 56)

"Analysts at the NFPA, the USFA and the Consumer Product Safety Commission developed the specific basic analytical rules used for this procedure. "The National Estimates Approach to U.S. Fire Statistics," by John R. Hall, Jr. and Beatrice Harwood, provides a more detailed explanation of national estimates. A copy of the article is available online at http://www.nfpa.org/osds or through NFPA's One-Stop Data Shop." (Page 57)

Discussion

Clearly, the excerpts above indicate that citing a single statistic for the reliability of sprinkler systems is misleading. There are major differences in the reliability of wet and dry sprinkler systems and the reliability of sprinkler systems by building occupancy.

The good news is that the reliability statistic for sprinkler systems in the occupancy were most fire fatalities occur, residential occupancies, is 95 percent and, interestingly enough, the sprinkler systems with the worst reliability statistics are in occupancies where the "life hazard" is low, industrial and storage occupancies. The only exception to these conclusions is the reliability of sprinkler systems protecting educational occupancies.

Given the statistics cited in the 2010 NFPA report on sprinkler system reliability, it would appear that the Alliance for Fire and Smoke Containment and Control has been "crying wolf" about the reliability of sprinkler systems. In office buildings, grocery stores, department stores and in dwellings (single-family and multi-family), the reliability of sprinkler systems is in the 94-95 percent range. That's very close to the reliability statistic that was assumed before the AFSCC retained the services of William Koffel and began their attempt to "trash" sprinkler systems' reputation for reliability.

While 90 percent and higher reliability is very good for systems which stand idle for years, and even decades, before being called onto operate effectively, the reliability of sprinkler systems can be improved simply by implementing the routine inspection of systems by trained fire department personnel (per the requirements of NFPA 25). With the cause of 53 percent of the failures of sprinkler systems due to closed water supply valves, there is no reason why the reliability statistic for sprinkler systems can't easily be increased.

Obviously, with the disparity in reliability statistics between wet and dry systems, more attention needs to be paid to the maintenance of the protection provided by dry sprinkler systems. Also, obviously, more attention needs to be paid to maintenance of sprinkler systems protecting educational, industrial and storage buildings.

Now that the reliability of sprinkler systems has been put under the microscope and, for many occupancies considered to be high "life hazards", found to be very close to what was previously assumed, perhaps it's time to take a look at the reliability of passive fire protection features. It's my opinion that the reliability of passive fire protection features is not likely to be anywhere near close to the reliability of sprinkler systems. Given this, perhaps additional "sprinkler trade-offs" should be included in our model building codes.

It's interesting to note that the only solutions to concerns about the reliability of sprinkler systems put forward by the Alliance for Fire and Smoke Containment and Control are proposals to eliminate "sprinkler trade-offs" and increase passive fire protection requirements in buildings protected by a sprinkler system. If the reliability of sprinkler systems is of concern, it would seem that the obvious way to address the problem would be to propose means of improving the reliability of sprinkler systems. Improving the reliability of sprinkler systems would, of course, be the simplest and most cost-effective means of addressing the issue.

One certainly has to wonder why William Koffel hasn't spoken out on how to improve the "problem" of the reliability of sprinkler systems. Given that Koffel is a former president of the SFPE and has been a long time member of the NFPA 13 committee, you would think that he has the standing to be able to have a significant impact on the "problem".

Perhaps the reason why improving the reliability of sprinkler systems is not of interest to the AFSCC is that the concept of "balanced fire protection" has more to do with market share for the manufacturers of passive fire protection products than it has to do with life safety. Just something to ponder the next time you hear the AFSCC mention the concept of "balanced fire protection" or the reliability of sprinkler systems.

Hopefully, the AFSCC and William Koffel will assist in the cause of increasing the reliability of sprinkler systems by promoting the enforcement of NFPA 25 by the fire service. With the AFSCC's and Koffel's help, we should be able to reduce the failure rate of sprinkler systems, thereby eliminating their concern about the reliability of sprinkler systems and the need for all the redundant passive fire protection presently being promoted by the AFSCC.

If both the AFSCC and William Koffel get involved in solving the problem as suggested above, the level of safety provided in buildings protected by a sprinkler system will increase and building construction costs will be reduced (because the need for the redundant passive fire protection reduced). Increasing the level of safety, while at the same reducing building construction costs, sounds like the ideal solution to the "problem" highlighted by both the AFSCC and Koffel.

Is the AFSCC more interested in providing cost-effective solutions to providing building safety for the public or in promoting passive fire protection products? If the AFSCC and Koffel don't get on the "bandwagon" to increase the reliability of sprinkler systems, we'll know that the "balanced fire protection" concept was all about using "the balanced fire protection" concept just to "make a buck".

Many of us already figured out a long time ago that the "balanced fire protection" concept was not about saving lives, but about "bucks". Using public safety simply as a means to "line one's pockets" is a pretty cynical way of making a living. Of course, the above are just my opinions on the issue of "balanced fire protection" and the reliability of sprinkler systems.

Note: The NFPA report discussed above can be downloaded (at no cost) at the following internet address:

http://www.nfpa.org/assets/files//PDF/OSsprinklers.pdf

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