Water Supply Adjustments: Where We're At

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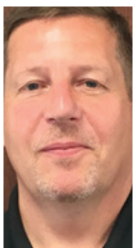

You may have heard reference to "The Sprinkler Project" before, but may not have known its meaning. It refers to the group of NFPA sprinkler-related standards including, but not limited to, NFPA 13, NFPA 13D, NFPA 13R, NFPA 24 and NFPA 291. These documents play a huge part in everything our members do for a living; from manufacturing sprinklers, pipe, hangers, fittings and other products to layout and installation of systems, and the many other services offered by our members. NFSA has been, is, and will continue to be integrally involved in the NFPA revisions of all sprinkler related codes and standards. After all, we are the voice of the sprinkler industry.

The idea of having a mandatory water supply adjustment or providing a workable framework for adjustments has been the source of many heated discussions over the past few years. This article provides a concise snapshot of the issue.

Background

Over the past two NFPA revision cycles (A2015, A2018), the issue of requiring mandatory water supply adjustments has been questioned. There are many that believe adjustments should be made by having a fixed pressure reduction, a percent reduction or some defined formula for adjustment. Others think that this is unnecessary.

The predictive accuracy of water supply data is being questioned by those that think an adjustment is needed. There are concerns that the water supply data gathered from a single hydrant flow test may be unsuitable to predict the actual available water supply in the future. Many argue that the data does not accurately portray the potential for variation in a water supply and that an adjustment needs to be made. However, a big part of the problem is that most public and private water distribution systems have different operating parameters based on the needs of the communities served. Water purveyors are guided by the American Water Works Association (AWWA) through a series of recommended practices. These documents do not always correlate with NFPA requirements.

Water distribution systems are primarily intended to provide potable water to consumers and the fact that these systems also provide water for fire protection should really be considered a bonus. Most of the controversy could be solved by improved communication between the fire protection community and water purveyors. The terminology used in the two industries is sometimes a little different.

Asking the right questions of the water purveyor might help solve many issues. Rather than asking if there is a mandatory water supply adjustment, it might be more appropriate to ask questions about when peak demands occur or what kind of variance they typically experience in their systems (high and low gradients). What are the daily and seasonal peak demands? When do they typically occur? How does the system operate? Is the system gravity fed? Do system pumps react automatically in response to high demand or are they operated manually? Are there any pressure reducing valves or similar devices in the system that might restrict water supplies in the event of a fire demand? These are some of the questions that will help to characterize the water supply. The answers to these questions are key to assessing the reliability of flow tests. Understanding the nuances of the answers will support a position for using hydrant test data outright, or deciding if adjustments are needed.

The AWWA manual on Distribution System Requirements for Fire Protection states that *"the design of sprinkler systems requires knowledge of the water pressure in the street. However, there is no such thing as a single, constant water pressure in the street that should be used for design. The pressure in water mains varies over time due to a large number of factors"*. This is an important clarification since we ask these people for static water pressure all the time. They do not consider these systems static, ever. They are probably looking at us like we have three eyes.

When we refer to static pressure in a water supply, we really only mean the "normal pressure" (the pressure exerted against the pipe walls which excludes the velocity pressure of water flowing in the pipe) in the water supply system at that location when we are not flowing water at the flow hydrant(s). Strictly speaking, the water purveyors are correct; we do not measure true static pressure during hydrant flow tests. Instead, we assume that the difference between the "normal pressure" and "static pressure" is insignificant for our purposes. (this is the source of the potential problem with predictivity.)

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The approach to dealing with the variance of a water supply is handled much differently in the fire protection industry. NFPA 13, section 23.2.1.1 states, *"Where a waterflow test is used for the purposes of system design, the test shall be conducted no more than 12 months prior to working plan submittal unless otherwise approved by the authority having jurisdiction."* The annex A.23.1.1 suggests alternative means be considered where droughts and other concerns are present. This could include predictive modeling, an analysis of historical data or some other practice prescribed by the water purveyor and acceptable to the AHJ.

The Current Approach

NFPA 291-2016, Recommended Practice for Fire Flow Testing and Marking of Hydrants, provides a recommended methodology for conducting hydrant flow tests. NFPA 291, section 4.2.1 suggests that tests should be conducted during periods of ordinary demand. Two or more hydrants are used to conduct the testing. The test hydrant (where static pressure and residual pressure data is recorded) would be closest to the fire service main (lead-in) for the sprinkler system and the flow hydrant(s) (where pitot pressure(s) is/are recorded) would be located downstream. NFPA 291, section 4.3.6 suggests that a minimum 25% drop in pressure should be attained. Additional hydrants located further downstream would be used if insufficient pressure drop is attained. However, in most cases achieving a flow rate equal to or greater than the sprinkler system demand will be deemed acceptable. This is especially important where water conservation is of grave concern.

The actual test procedure is described in NFPA 291, section 4.5. A hydrant cap with a test gauge is connected to the test hydrant as shown in Figure 1. The static water pressure is recorded at this location with the test hydrant open and capped. Some systems will have very little variance and the gauge will remain relatively stable at a given pressure. However, others will have oscillation related to service usage, which is why the water purveyors say it is not static. In general, the average reading is recorded.

Figure 1 – Residual Hydrant with Test Cap and Gauge

The flow hydrant is opened to begin the test with one or more 2 ½-inch outlets being opened, then the residual pressure is recorded at the test hydrant concurrently with the pitot pressure measurement(s). (Other types of flow test measuring equipment such as the diffuser, shown in Figure 2, can be used in place of a traditional pitot tube.) It is common for the gauge needles to be oscillating significantly when reading the residual pressure at the test hydrant and the pitot pressure at the flow hydrant, so we use the average pressure readings observed.

Figure 2 – Flow Hydrant with Diffuser

The equation $Q = 29.83\, c_d d^2 (p_{pitot})^{0.5}$ is then used to estimate the flow from the hydrant based on the velocity pressure measured with the pitot gauge, where Q is flow in gallons per minute (gpm), C_d is the hydrant coefficient of discharge (usually 0.7 – 0.9) and d is the hydrant outlet diameter in inches. The data is usually plotted on a special semi-exponential graph paper with pressure measured in the vertical axis and flow measured on the horizontal axis at the 1.85 power (nearly squared) as shown in Figure 3.

Looking at a hypothetical hydrant flow test, a static pressure of 100 psi, a residual pressure of 70 psi and a flow of 1,500 gpm were achieved. This data is shown in Figure 3 which provides a convenient graphic representation of the predicted pressure available from the water supply at any given flow.

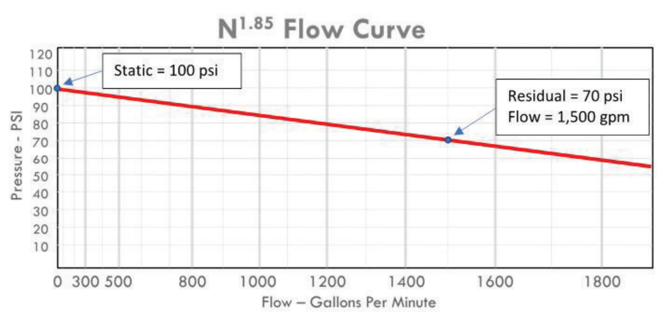

Figure 3 – Hypothetical Water Flow Test Graph

Where We Are Now

During the A2015 code cycle, an attempt was made through both public inputs (PIs) and public comments (PCs) to mandate adjustment to water supply data. These comments sought to mandate a 5% reduction of the static water pressure and a 5% reduction of the residual water pressure at the tested flow rate. This adjustment was intended to result in a shift in the available water supply to

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provide a presumed margin of safety.

The technical committees (TCs) could not reach consensus on the issue of including a mandatory 5% adjustment so a request was submitted to the NFPA Fire Protection Research Foundation (FPRF) to study the issue. The TCs voted to "Reject, But Hold" several related water supply adjustment PCs. This meant that regardless of any new PIs submitted as part of the A2018 cycle, these PCs would automatically be brought to the NFPA technical committees for discussion.

The FPRF sponsored research regarding water flow data adjustments which was conducted by Jed Kurry, P.E., Mark Hopkins, P.E., and Donald Hopkins, P.E. of Jensen Hughes. The final report titled, "Quantification of Water Flow Data Adjustments for Sprinkler System Design," was published in September 2015.

There were several key findings of the research, which led to the conclusion that a single formula or fixed adjustment would not be appropriate for all public and private water distribution systems. The operating parameters for the various water distribution systems throughout the United States and internationally are too broad to allow for a single fixed adjustment or formulaic adjustment. The authors stated,

> *The goal of this research was to identify the variables in water supplies that affect hydrant flow tests which are used to design water based suppression systems. The results of this research were intended to be used to provide adjustments to water supply data to ensure that the data used for fire protection system designs represents the actual system conditions during peak demand and is adjusted based on system parameters such as tank level during testing and normal system operations.*
>
> *Due to the limited available literature regarding the topic of water supply adjustments, insufficient data was considered available to support recommendations for development of adjustment factors at this time. The data was considered insufficient for the following reasons: 1) there is a lack of data associating flow rates and available pressure, 2) there is insufficient data to provide meaningful comparisons between regions and within specific regions, 3) there is a lack of data for all identified variables, and 4) data was not limited to a single variable or discrete number of variables, which would allow for development of adjustment factors.*

The authors presented the findings of the study at the 2015 NFPA Conference and Expo. In addition, the authors presented the data to the NFPA Sprinkler Project technical committee members at the start of the A2018 cycle during the pre-First Draft Meeting.

In addition, several PIs were made during the A2018 cycle to provide either a 10 psi or 10% adjustment to hydrant flow test data for public and private water distribution systems. The issue was met with split votes and heated debate. At the completion of the NFPA 13 First Draft meetings, a series of requirements was added which ended with a 10% adjustment for water supplies where prior knowledge is unavailable. This would provide competitive advantage to anyone knowing the water supply and would potentially penalize those without knowledge.

As part of the first draft, information on water supply adjustments was relocated to Chapter 5 of NFPA 13 as part of the 2019 edition reorganization. The reorganization of the NFPA 13-2019 document should be considered tentative until the document is balloted and accepted at the 2019 NFPA Technical Session. The requirements for adjustments are found in the sub-sections for Connections to Waterworks Systems (NFPA 13-2019, section 5.2.2). The requirements related to adjustments are found in NFPA 13-2019, section 5.2.2.2.1 and its sub-sections. These sections state,

> *NFPA 13-2019, 5.2.2.2.1 Where a waterflow test is conducted, the volume and pressure available for use for a fire protection system shall be determined in accordance with 5.2.2.2.1.1. If knowledge of the water supply is unavailable, the volume and pressure shall be determined in accordance with 5.2.2.2.1.2.*
>
> *NFPA 13-2019, 5.2.2.2.1.1* Water supply adjustments shall be based on knowledge of the water supply and engineering judgment, taking into account daily and seasonal fluctuations, not extreme conditions.*
>
> *NFPA 13-2019, 5.2.2.2.1.2* If knowledge of the water supply is unavailable, the following formula shall be used to determine volume and pressure:*

$$P = (P_R - P_S) * [Q/Q_R]^{1.85} + P_L$$

where:

- P = pressure available from the water supply for fire protection at given flow (Q)
- P_R = residual pressure measured during the waterflow test
- P_S = static pressure measured during the waterflow test
- Q = flow that will be used to calculate the available pressure from the water supply
- Q_R = flow measured during the waterflow test
- P_L = expected low static pressure at the location of the test results accounting for daily and seasonal fluctuations (not extreme conditions) obtained from the water utility

NFPA 13-2019, 5.2.2.2.1.3 Where the water authority does not provide a value for PL, the value of PL shall be calculated from the following formula:

$$PL = Ps * (0.9)$$

NFPA 13 requires every sprinkler system to have at least one automatic water supply. NFPA 13-2016, section 24.1.2 states, *"Water supplies shall be capable of providing the required flow and pressure for the remote design area determined using the requirements and procedures as specified in Chapters 11 through 22 including hose stream allowance where applicable for the required duration."*

In the simplest terms, if the water supply meets the sprinkler system demand the requirement is satisfied. However, this isn't

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always clear. This could be why there is debate on this topic. On the one hand, testing is done every day with very good success. The people doing the tests communicate well, test data is interpreted properly, systems are designed and installed without issue. Overall, the operational performance of sprinkler systems has historically been very good. Fire loss data is not supporting mandatory water supply adjustments.

On the other hand, what is being done is not perfect. In some instances, there are inexperienced people conducting tests, there are tests performed by people that do not understand the systems they are testing. There are also instances where arbitrary adjustments are being applied. This should probably be the focus, not mandating fixed adjustments to every system, many of which have little or no variance over time. The issue at hand is not so much how flow testing is conducted so much as it is how flow test results are interpreted and applied in light of historical water system data that can only be provided by the water purveyor.

There have been many concerns raised about mandatory adjustments, such as, the possibility that there could be multiple adjustments made. This could happen if an adjustment is made during the preparation of construction documents by a design professional and subsequently an additional adjustment is mandated by an AHJ as part of the shop drawing development. Concerns have also been raised about AHJs skipping the requirements of NFPA 13-2019, sections 5.2.2.2.1.1 and 5.2.2.2.1.2 relating to knowledge of systems and engineering judgement. This would result in a mandatory 10% adjustment in accordance with *section* 5.2.2.2.1.3.

Additional concerns have been raised that the mandatory adjustment might require fire pumps where they would not otherwise be required. Without having flexibility to accept a 9%, 8% or 7% adjustment without a fire pump, there would be cause for contractors to install fire pumps and no allowance for AHJs to permit omission with a modification to the requirements of the standard. This scenario recently played out in the U.S. where some jurisdictions have been requiring 10% to 20% adjustments to water supply data regardless of the time of year, time of day and operating conditions of the water supplies.

Using the hypothetical test results used earlier with a 20% adjustment would result in a static pressure of 80 psi and a residual pressure of 56 psi at 1,500 gpm as shown in Figure 4. This could create a challenge when the demand is marginally below the water supply curve. This can be even more frustrating and costly when the shift results in the need for a fire pump, which would not otherwise be necessary.

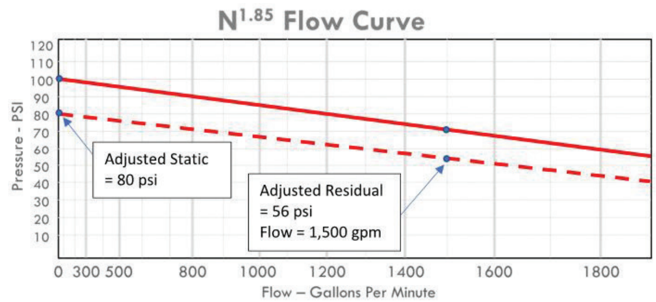

Figure 4 – Hypothetical Adjusted Water Flow Test Graph

This is a case of being too conservative, e.g. if a little is good a lot must be much better. In many cases, fire pumps are and have been required simply due to these mandated adjustments. Representatives of the NFSA Engineering Department have met with many AHJs to show that excessive mandatory adjustments not based clearly on known water supply variations do not necessarily provide better fire protection, but rather can lead to reduced dependability and increased cost. Eventually, this is going to have bad implications for the fire protection industry due to the cost associated with the installations and maintenance of this unnecessary, but now mandated equipment.

During the Second Draft meeting, the requirements were softened and all references to fixed percentages were removed. This is a case where working with other stakeholders may pay off. It is too early to tell the outcome, but for now there are no mandatory adjustments in the NFPA sprinkler related documents. •