NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

TechNotes

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This edition of TechNotes has been prepared by Roland Asp, C.E.T., Manager of Codes and Standards for the National Fire Sprinkler Association.

Hydraulic calculations — Why we need to know how to perform them manually

Hydraulic calculations are a mainstay of our industry today. These calculations determine the most important aspect of the fire protection system being designed; will the system, as designed and given the available water supply, be able to provide enough water at the required density to successfully control or suppress a fire? The majority of fire protection systems use hydraulic calculations to size piping, to determine the demand of the fire protection system and to determine the necessary size and adequacy of the water supply.

Today, most of us use computer-based software programs to aid us in performing these calculations. These capable and powerful programs streamline the hydraulic calculation process by taking our input information and running the calculations for us. As long as the correct information is inputted into the program, an accurate calculation can be produced in a fraction of the time of a manual or “old fashioned” hydraulic calculation.

Why then, if the computer-based hydraulic programs are so capable, should a layout technician learn to perform calculations manually?

The overriding reason to learn how to perform manual hydraulic calculations is to be a better layout technician and produce better sprinkler system plans and layouts.

The advent of hydraulic calculation programs has certainly been an enormous benefit to the layout technician, but if the technician does not understand the formulas and procedures behind the calculation process, the calculation may be compromised.

The knowledge gained by understanding and practicing the manual hydraulic calculation methods will reinforce the basic concepts of hydraulics and the interdependency of the various aspects of the layout. This understanding of the concepts of hydraulic calculations will help the technician to develop the “feel” for the fire sprinkler system that cannot be learned through merely inputting data into a computer.

A comprehensive understanding of hydraulic concepts, including the Hazen-Williams formula and the formula for calculating the flow, the pressure and the k-factor is not a prerequisite for performing a computer-based hydraulic. If the correct information is inputted into the software, these important values will be incorporated into the calculations. However, without this understanding, it is too easy to input incorrect information and nearly impossible to recognize inconsistencies in the results.

A few of the formulas that we need to use and understand include:

Hazen Williams Formula: $$P_f = \frac{4.52 \times Q^{1.85}}{C^{1.85} \times d^{4.87}}$$

P_f = friction loss per foot of pipe in pounds per square inch (psi)
Q = flow in gallons per minute (gpm)
C = pipe roughness coefficient
d = interior pipe diameter in inches

Flow from an orifice: $$Q = k\sqrt{P}$$

Q = flow in gpm
k = constant dependent on orifice size and configuration
P = pressure in psi

Pressure: $$P = \left(\frac{Q}{k}\right)^2$$

K-factor: $$k = Q/\sqrt{P}$$

Know the flow – old school

Although most hydraulic calculation programs can be utilized to determine the hydraulically remote area, this vital aspect of the design still must be confirmed by the technician. A thorough understanding of hydraulics that is gained from performing calculations the “old fashioned way,” will give us insight into which portion of the system is truly the hydraulically most demanding area. This aspect of the design is not always obvious and can be difficult to determine. Once we have been “hands-on” with hydraulic calculations, the variables of flow from an orifice, design densities, pipe-sizing and their hydraulic effects, will become second nature and aspects of design such as determining remote areas to calculate will become easier to determine. This determination is vital to the

sprinkler design and in the end is no more than a guess to be proven by the calculations. A working knowledge of hydraulics will help make this guess an educated one.

Correct determination of the best pipe sizing and layout configuration is also a product of experience and understanding of hydraulic principles. It is the goal of the layout technician to produce the most efficient system, both hydraulically and economically. Again, the most efficient sizing of piping and system layout is not always obvious. It may be better to have larger mains and smaller branch lines or the opposite may make for a more efficient system. This can be determined by imputing all the various pipe-sizing possibilities.

Defending the design – calculations and plan review

The hydraulic calculations are submitted for plan review. The authority having jurisdiction (AHJ) will review the calculation printout and spot check the results to confirm the system's performance. It is the responsibility of the layout technician to explain and defend the results of the calculations. If the technician is comfortable with only inputting the data into the program and not the concepts behind the data, it will be difficult to defend the calculations. The general goal of the shop drawings and hydraulic calculation printouts is to communicate important information. If the technician cannot adequately explain the data on these printouts to the plan reviewer, the goal of communication has not been achieved. A perfectly acceptable sprinkler layout plan and hydraulic calculation could be rejected if the layout technician is not comfortable with the hydraulic principles and cannot effectively justify the calculations to the AHJ. Those who have experience actually using the formulas and procedures in hydraulic calculations will be comfortable with the concepts be able to effectively explain and defend the calculation resulting in an approved sprinkler plan.

In this day and age, with the advent of capable hydraulic calculation software programs, why is it important that the layout technician learn to perform manually hydraulic calculations? The answer is to become a better layout technician and to truly understand the concepts of hydraulics as they relate to fire sprinkler systems. Manually calculating the systems will give an understanding of the hydraulic concepts that is not possible to gain by simply inputting information into a computer. The best layout technicians will combine the best of both methods, using the software to calculate the system quickly and accurately with the knowledge that they gained from practicing the "old fashioned" calculation method. The manual method will help hone the technician's skill set and help them to gain the elusive "feel" that is a mark of good layout technicians.

Get better at manual calculations – NFSA training

The National Fire Sprinkler Association can help teach you how to perform manual hydraulic calculation through various resources. These calculations are covered extensively in The Layout Technician Training Class and in our publication “Layout, Detail and Calculation of Fire Sprinkler Systems". Additionally, the TechTuesday “Manual Calculations” explores this topic in a recorded webinar.

Layout Technician Training - Virtual Class

Layout Detail and Calculation of Fire Sprinklers Text Book

Tech Tuesday Manual Calculations

Top Tech Competition

The 2021 Top Tech Competition will be held in October 2021. The window for testing will open summer 2021. We look forward to your participation. More details will be out soon. Keep studying!

Join the NFSA Team

We are searching for a Fire Protection Engineer and a Manager of Training and Education to join Team NFSA!

Fire Protection Engineer

This position supports the mission by providing technical services including representation on committees, research of sprinkler system performance, preparing written reports and developing and teaching seminars. Please view the entire position description and apply here: **Fire Protection Engineer Position**

New EOD Process

Starting on July 15, 2020, the NFSA has a new EOD process where members can submit questions, track the progress, and view their EOD cases. The step by step process is detailed in **TechNotes #442**.

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