BASIC HAND CALCULATIONS

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1

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Travis Mack is a NICET Level IV certified fire sprinkler system engineering technician with more than 35 years of experience in fire sprinkler system design, hydraulic calculations, and fire protection education.

He currently serves as a Subject Matter Expert & Support and Training Specialist with MEPCAD and Executive Director of the Online Fire Sprinkler Academy, where he develops and delivers technical training for fire sprinkler designers and industry professionals.

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3

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4

Objective:

- By the end of this session, participants will have a working understanding of the basic hydraulic principles and formulas used to calculate a fire sprinkler system and how those formulas work together during a hydraulic calculation.
- Participants will learn to:
  - Identify and apply the basic hydraulic calculation formulas.
  - Calculate sprinkler discharge using the K-factor formula.
  - Determine friction loss through pipe using the Hazen-Williams formula.
  - Account for elevation pressure changes.
  - Calculate pressure and flow as water moves through a sprinkler system.
  - Perform a basic manual hydraulic calculation of a simple tree system from the remote sprinkler back to the water supply.
  - Understand the hydraulic calculation well enough to recognize whether computer-generated results are reasonable.
- **The Goal**
  - **Understand what the software is doing—not just how to push the Calculate button.**

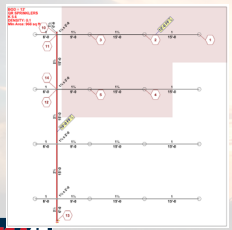
5

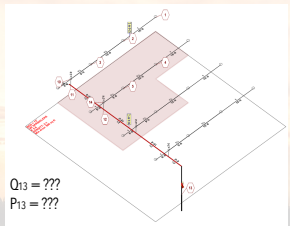
Formulae:

- Base Formulae:
  - Q = flow in GPM; K = k-factor, P = pressure in psi.
  - $Q = K\sqrt{P}$
  - $K_{eq} = Q/\sqrt{P}$
  - $P = (Q/K)^2$
- Pressure change due to elevation:
  - Pe = 0.433 psi / ft
- Pressure loss per ft (Hazen Williams Equation)
  - $(4.52 \times Q^{1.85}) / (C^{1.85} \times d^{4.87}) = P_f$
  - 4.52 x Q x^y 1.85 / C x^y 1.85 / d x^y 4.87
  - Some calculators use ^ in lieu of x^y

6

Our System





Q_{13} = ???
P_{13} = ???

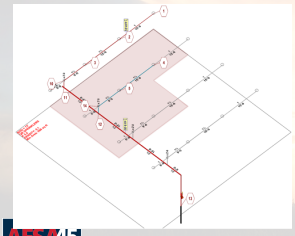
7

Paths:

- Primary Path:
  - Route from most demanding sprinkler to source.
  - Node 1 → Node 13 in Our System
- Attachment Paths:
  - Connect to the Primary Path
  - Must End with Creating an Equivalent K-Factor (Keq)
  - Node 4 → Node 12 in Our System

8

Paths



- Primary Path (RED)
- Attachment Path (BLUE)

9

Nodes:

- Reference Points
- Where Required
  - Where there is a change in flow out of the system
  - Where there is a change in C-Factor
  - Where there is a change in the internal diameter
  - Note: Anytime there is a change in the Q, C or D of Hazen Williams formula
- Optional Nodes:
  - Top of RN, Top of Riser, Bottom of Riser, etc.
  - Where ever you want

10

How to assign fittings:

- NFPA 13 gives specific wording on how to assign fittings in our demand calculations
  - The fitting at the intersection of a drop/sprig/armover and a branchline goes to the drop/sprig/armover.
  - The fitting at the intersection of a branch line and riser nipple goes to the branch line
  - The fitting at the intersection of a cross main and riser nipple goes to the riser nipple.
  - The fitting at the intersection of a cross main and feed main goes to the cross main

11

Fitting Modifiers:

- Fittings are generally listed as equivalent length for Sch 40 and C120.
- When attached on pipe with diameters different than Sch 40
  - Modifier equals (Pipe ID / Sch 40 ID)$^{4.87}$
  - Longer Leq for pipe with larger ID than Sch 40. Shorter for pipe with smaller ID than Sch 40.
- For C factor different than 120
  - C100 = 0.713 (shorter Leq)
  - C140 = 1.33 (longer Leq)
  - C150 = 1.51 (longer Leq)
- Modifiers are COMPOUNDING

12

Calculation Sheets (Pipe Analysis Sheet):

- Standard format since around 2002
- Used to help organize data for calculations
- Enter known information first
- Proceed from left to right as you work the sheet

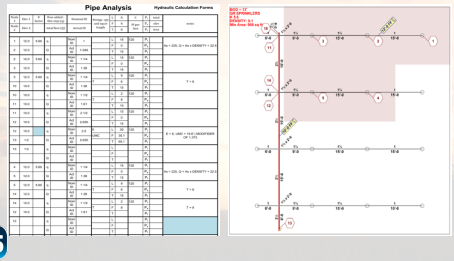
13

Rounding Conventions:

- Pressure: 0.0
- Flow: 0.0
- Length: 0.0
- Diameter: 0.000
- Density: 0.00
- K-Factor (Keq): 0.00
- Fitting Adjuster: 0.000
- P_f: 0.000

14

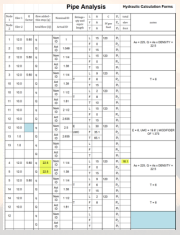
Filling in Calculation Sheets (Known Information)



15

Filling in Calculation Sheets (Getting Started):

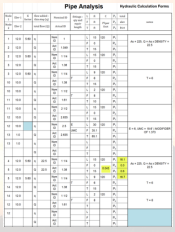
- Start with Attachment Paths
- q = As x Density
  - q = 0.10 x 225 = 22.5
  - Q = q at start of a path
- $Pt = (q/k)^2 = (22.5/5.6)^2 = 16.1$



16

Node 4 → 5:

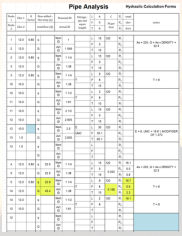
- Pe = Elev Node 4 – Elev Node 5 x .433
  - 12 – 12 = 0 x .433 = 0
- P_f / ft= 4.52 x $Q^{1.85}$ / $C^{1.85}$ / $d^{4.87}$
- P_f / ft= 4.52 x $22.5^{1.85}$ / $120^{1.85}$ / $1.380^{4.87}$
- P_f / ft = 0.043
- P_f = 0.043 x 15 = 0.6



17

Node 5 → 14:

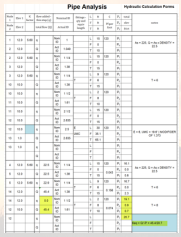
- Pe = Elev Node 5 – Elev Node 14 x .433
  - 12 – 12 = 0 x .433 = 0
- $q = k\sqrt{p} = 5.6 * \sqrt{16.9} = 22.9$
- Q = q + Q above = 45.4
- P_f / ft= 4.52 x $45.4^{1.85}$ / $120^{1.85}$ / $1.380^{4.87}$ = 0.156
- P_f = Pf/ft * L = 2.3
- $P_{t14} = P_{t5} + P_e + Pf = 16.7+0+2.3 = 19.1$



18

Node 14 → 12:

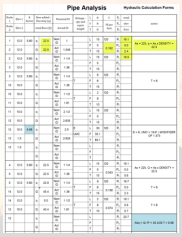
- Pe = 12 – 10 = 2 x .433 = 0.9
- $q = k\sqrt{p} = 0 * \sqrt{19.1} = 0$
- Q = q + Q above = 45.4
- P_f / ft= 4.52 x $45.4^{1.85}$ / $120^{1.85}$ / $1.61^{4.87}$ = 0.074
- P_f = Pf/ft * L = 0.7
- P_{t12} = 19.1+0.9+0.7 = 20.7
- Keq = $Q/\sqrt{P}$ = 45.4/20.7 = 9.98



19

Node 1 → 2:

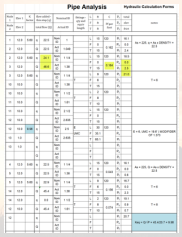
- q = As x D = 225 x 0.1 = 22.5
- Q = q at start of path
- Pe = 12 – 12 = 2 x .433 = 0.9
- P_f / ft= 4.52 x $22.5^{1.85}$ / $120^{1.85}$ / $1.049^{4.87}$ = 0.162
- P_f = Pf/ft * L = 2.4
- P_{t2} = 16.1+0+2.4 = 18.5



20

Node 2→ 3:

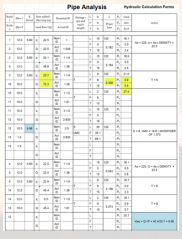
- q = k x √p = 24.1
- Q = q + Q above = 46.6
- Pe = 12 – 12 = 0 x .433 = 0
- P_f / ft= 4.52 x $46.6^{1.85}$ / $120^{1.85}$ / $1.380^{4.87}$ = 0.164
- P_f = Pf/ft * L = 2.5
- P_{t3} = 18.5+0+2.5 = 21.0



21

Node 3→ 10:

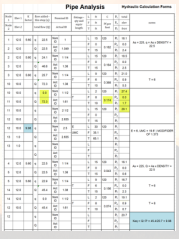
- q = k x √p = 25.7
- Q = q + Q above = 72.3
- Pe = 12 – 10 = 2 x .433 = 0.9
- P_f / ft= 4.52 x $46.6^{1.85}$ / $120^{1.85}$ / $1.380^{4.87}$ = 0.368
- P_f = Pf/ft * L = 5.5
- P_{t10} = 21.0+0.9+5.5 = 27.4



22

Node 10→ 11:

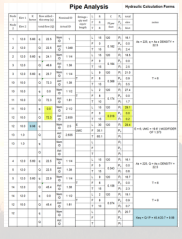
- q = k x √p = 0
- Q = q + Q above = 72.3
- Pe = 10 – 10 = 0 x .433 = 0
- P_f / ft= 4.52 x $72.3^{1.85}$ / $120^{1.85}$ / $1.61^{4.87}$ = 0.174
- P_f = Pf/ft * L = 1.7
- P_{t11} = 27.4+0+1.7 = 29.1



23

Node 11 →12:

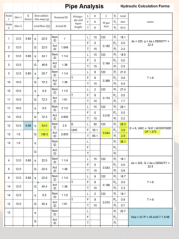
- q = k x √p = 0
- Q = q + Q above = 72.3
- Pe = 10 – 10 = 0 x .433 = 0
- P_f / ft= 4.52 x $72.3^{1.85}$ / $120^{1.85}$ / $2.635^{4.87}$ = 0.016
- P_f = Pf/ft * L = 0.2
- P_{t12} = 29.1+0+0.2 = 29.3



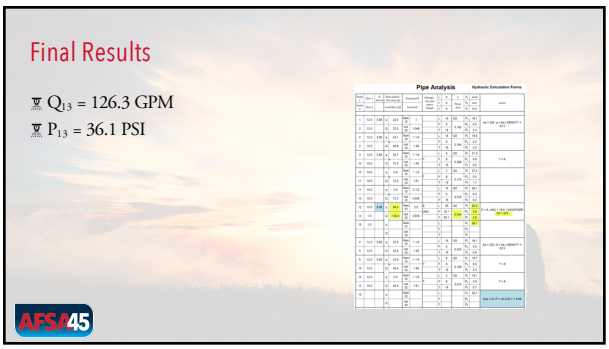
24

Node 12 → 13:

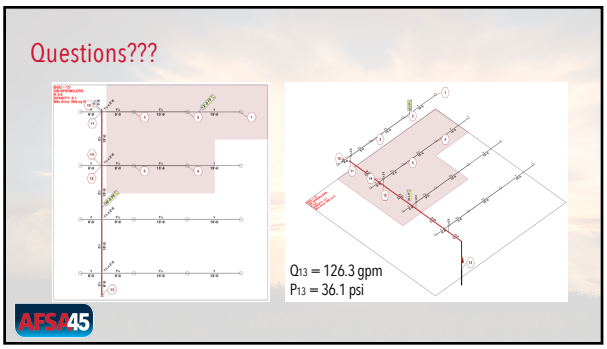
- q = k x √p = 54.0
- Q = q + Q above = 126.3
- Pe = 10 – 1 = 9 x .433 = 3.9
- P_f / ft= 4.52 x $126.3^{1.85}$ / $120^{1.85}$ / $2.635^{4.87}$ = 0.044
- P_f = Pf/ft * L = 2.9
- P_{t13} = 29.3+3.9+2.9 = 36.1



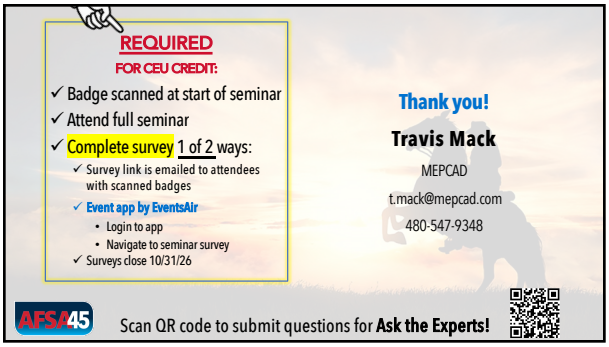
25


Final Results
Q_{13} = 126.3 GPM
P_{13} = 36.1 PSI
Pipe Analysis
Hydraulic Calculation Forms
AFSA45

26


Questions???
Q_{13} = 126.3 gpm
P_{13} = 36.1 psi
AFSA45

27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Thank you!
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28

2027 Training Schedule

WEBINARS

1/6	Updates to NFPA 20
1/20	Calculating Pressure Reducing Hose Valves
2/3	Consumer Alert: Nitrogen in Sprinkler Systems
2/17	Reviewing Hydraulic Calculations
3/3	Updates to NFPA 13, 2028 Ed.
3/17	Updates to NFPA 13R & 13D, 2028 Eds.
4/7	Topic Coming Soon
4/21	NFPA 25: Roles & Responsibilities
5/5	Standpipe Flow Test Procedures
5/19	Storage 101
6/2	NFPA Technical Meeting - Voting Guide
6/16	Topic Coming Soon
6/30	Topic Coming Soon
7/7	Updates to NFPA 14, 2027 Edition
7/21	Adjacent Hazards & Design Methods
8/4	Acceptance Testing
8/18	Modifications to Existing Systems
9/22	Topic Coming Soon
10/6	Seismic 101
10/20	Proposed Updates to NFPA 25, 2029 Ed.
11/3	Evaluating Fire Pump Flow Tests
11/17	Top 10 Tech Reviews
12/1	Designing Water Storage Tanks
12/15	Pump Room Layout

PROGRAMS

Feb 9 - Mar 5 Apr 20 - May 14 Aug 3 - Aug 27** Oct 26 - Nov 19	Beginning Design School*
Apr 26 - May 7 Nov 1 - 12	Intermediate Design School*
Feb 8 - 10** Apr 12 - 14 Jul 12 - 14 Oct 11 - 13	Sprinkler Hydraulics Calculations Workshop
Apr 19 - 21 Oct 18 - 20	Advanced Hydraulics Calculations Workshop
Feb 11** Apr 30 Jul 23 Sep 24	Introduction to the Fire Sprinkler Industry
Mar 1 - 3 May 17 - 19 Aug 16 - 18 Oct 18 - 20**	NFPA 25 Essentials Workshop
Jun 7 - 10 Sep 20 - 23	Experienced Inspector Skills Lab
Mar 4 - 5 May 20 - 21 Aug 19 - 20 Oct 21 - 22**	NFPA 25 Fire Pump Workshop
Spring Summer Fall	ITM Inspector Development Program* *This program is 20 months.*

** Hybrid course **At General Air Products Lab, Exton, PA*

AFSA46

September 8-11	Manchester Grand Hyatt San Diego, CA

For More Details Visit:
firesprinkler.org

AFSA
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Dates subject to change. Programs subject to minimum registrations.

rev 9/14/2026

Virtual Instruction Path (VIP)

for Sprinkler Fitting Apprentices

Level 1 - Begins January 2027

Level 2 - Begins February 2027

Level 3 - Begins January 2027

Level 4 - Begins March 2027

www.firesprinkler.org/VIP

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HANDS-ON WORKSHOPS FOR 2027

FEATURING AFSA'S TRAINING LAB

NFPA 25 Essentials Workshop

Mar | May | Aug | Oct

Description: Understand roles, responsibilities, and NFPA 25 ITM procedures through hands-on testing of wet systems, dry systems, and fire pumps.

NFPA 25 Fire Pump Workshop

Mar | May | Aug | Oct

Description: Develop practical NFPA 25 fire pump ITM skills, including no-flow and full-flow testing, water supply graphing, and performance evaluation.

Introduction to the Fire Sprinkler Industry

Feb | Apr | Jul | Sep

Description: This course is designed for those new to the industry. An introductory, wide-ranging 8-hour course that provides a broad overview of core fire sprinkler industry concepts for those new to the field.

Experienced Inspector Skills Lab NEW

Mar | Sep

Description: Take your ITM expertise beyond the basics. Designed for experienced technicians, this course combines focused classroom instruction with hands-on system lab training to strengthen your application of current NFPA 25 inspection, testing, and maintenance requirements. Refine fire sprinkler testing practices, improve documentation, deliver more consistent service, and help reduce liability while reinforcing knowledge commonly covered on certification exams.

Learn more about AFSA's fire sprinkler lab featuring functional risers, a spray room, fire pumps, and an interactive classroom.

firesprinkler.org/lab