Wildland Fire Hydraulics

Myth or Math

Author: Richard W. Hoffmann, Sr.
Creator of: Wildland Fire Hydraulics Slide-Rule and Android and iOS Phone Apps

'The Technology to Take the HEAT!'™

HFT Fire & Rescue Technologies & Equipment, LLC

...for your crew's SAFETY!

Back in the day, the best any Fire Apparatus Driver/Operator could hope for to estimate Wildland Fire Hydraulics in the field was a mechanical Slide-Rule or wallet cards that could only determine the Friction Loss (FL) component of this complex equation. But now upon the invention of the Android and iOS phone apps, PLUS, the 'Safety-Backup' of a mechanical Slide-Rule, ***TOTAL Engine Pressure (EP)*** *in mere seconds is finally attainable! Never before has such a complicated process been so simplified even a 'ROOKIE' can "**produce effective fire streams**" at "**the rated flow of the nozzle**" at every step of any hoselay…* ***to keep our crews SAFE!***

Truly, one of the GREATEST Fire Service SAFETY 'Breakthroughs' ever!

'In Remembrance and Honor of all those who have fought and fallen before us.'

HFT Fire and Rescue Technologies and Equipment, LLC

'The Technology to Take the HEAT!'™

Richard W. Hoffmann, Sr., CEO/Author/Patented Inventor

123 SW Oregon Trail Drive

Dallas, OR 97338

(877) HOSEROLLER [467-3765]

https://HydrauylicsApp.com - **http://BurnOver.HoseRoller.net** - **rich@hftfire.com**

Preface

After years of research and development, for the first time in Fire Service history, a complete wildland fire Engine Pressure (EP) hydraulics calculator is finally available. It not only accurately calculates Friction Loss (FL) of each given affected section of a wildland hoselay, but also includes Nozzle Pressure (NP), Appliance Loss (A), and (+) Head (H) to adequately estimate REQUIRED Engine Pressure (EP) to ***"Produce effective fire streams"*** at ***"the rated flow (GPM) of the nozzle..."***. This can now be calculated in mere seconds as mandated per NFPA 1002, Chapter 8, Wildland Fire Driver/Operator training standards. A qualified Emergency Services Instructor(s) per NFPA 1041 to be OSHA 29 CFR 1910.156 can be compliant to ensure your wildland firefighter **SAFETY** at all phases of progression of any wildland fire hoselay.

The development of both the Android and iOS phone apps and the mechanical Slide-Rule was inspired by the incredible need to provide every driver/operator of any fire apparatus engaged in wildland firefighting relief from the responsibility to accurately, yet quickly determine proper Engine Pressure (EP) in ***REAL-TIME***. This is now possible even while balancing resource management and direction, incident mitigation, and crew supervision to keep up with the continuous progression of a hoselay as calculation data and results change with the extended hoselay added in 100' length increments.

The integration of the basic features of a U.S. Geographic Survey (USGS) phone app and the Automatic Vehicle Location (AVL) technology with triple redundancy of the Global Positioning System (GPS), Cellular Site, and VHF radio triangulation can determine the 24/7 location of any fire apparatus in even the most remote areas of the North American continent. We can now meet the requirements of the ***"Holy Grail of Wildland Firefighting"*****; Section 5** of the ***"Wildfire Management Technology Advancement Act of 2018"*** within the ***"Natural Resources Management Act"*** that passed the Senate on February 12, 2019, and the House on February 26, 2019.

- ***"Develop and operate a tracking system to remotely locate the positions of fire resources****, including, at a minimum, any fire resources assigned to Federal Type 1 wildland fire incident management teams."*

The integration of the Wildland Fire Engine Pressure Hydraulics Calculator ensures the once estimated (+) or (-) Head pressure to be accurately calculated to provide the proper, ~~yet~~ SAFE Nozzle Pressure (NP) and water protection for every firefighter on the line. Adding the phone app's ability to locate personnel's bearing and distance from any fire apparatus (as a ***BENCHMARK***) on any USGS map, our ability to meet these firefighter safety requirements we've been struggling to secure for decades is finally here!

Table of Contents

'Fight the Fire and NOT the Hose!' …with 'Garden Hose Technology'

wild·land

noun

\ ˈwī(-ə)l(d)-ˌland \

Definition of *wildland*

: land that is uncultivated or unfit for cultivation

fire

/ˈfī(ə)r/

noun

1. 1.
combustion or burning, in which substances combine chemically with oxygen from the air and typically give out bright light, heat, and smoke.

hy·drau·lics

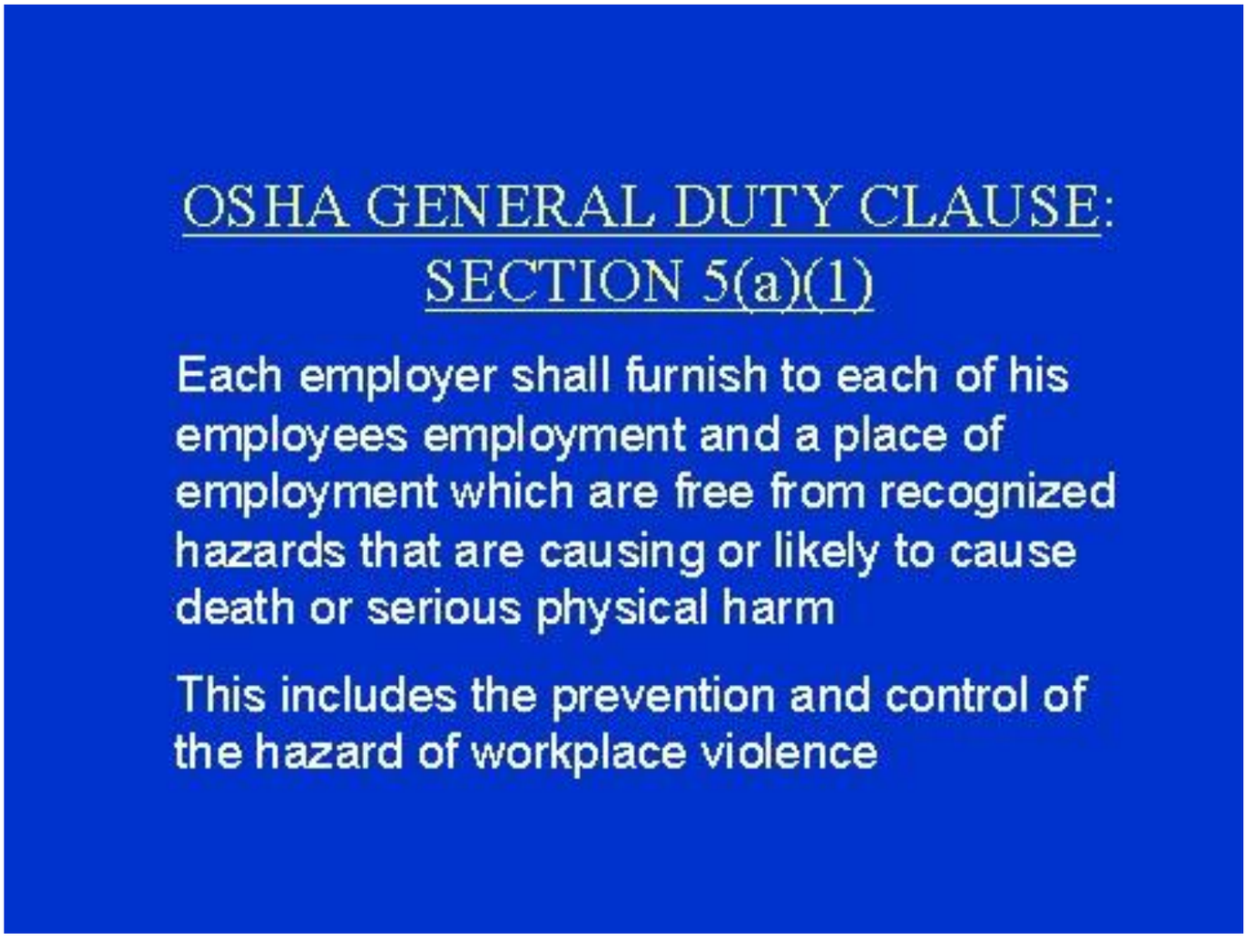
/hīˈdrôliks/

noun

noun: **hydraulics**; plural noun: **hydraulics**

1. 1.
the branch of science and technology concerned with the conveyance of liquids through pipes and channels, especially as a source of mechanical force or control.

Question*: *"How do these terms apply to OSHA's General Duty Clause to ensure the integrity of firefighter safety?"



NFPA 1002 – Standard for Fire Apparatus Driver/Operator Professional Qualifications

Chapter 8 Wildland Fire Apparatus

8.1 General:
The job performance requirements defined in Section 8.1 and 8.2 shall be met PRIOR TO qualifying as a driver/operator – wildland fire apparatus.

8.2 Operations:
8.2.1 Produce effective fire streams given the sources provided in the following list so that the pump is engaged, all pressure-control and vehicle safety devices are set, the rated flow of the nozzle is achieved, and the apparatus is monitored for potential problems:

(1) Water tank
(2) Pressurized source
(3) Static Source

(A) Requisite Knowledge. Hydraulic calculations for FRICTION LOSS AND FLOW using both the WRITTEN FORMULAS and estimation methods, safe operations of the pump, correct apparatus placement, personal safety considerations, problems related to small diameter or dead-end mains and low-pressure and private water supply, hydrant coding systems, and reliability of static sources.

NFPA 1041 - Standard for Fire and Emergency Services Instructors Professional Qualifications

1.1 Scope:
The Standard identifies minimum Job Performance Requirements (JPR's) for all Fire and Emergency Services Instructors up to and including Live Fire Instructor in Charge.

1.2.2 Purpose:
The intent of the standard shall be to ensure that (all) personnel serving as Fire and Emergency Services Instructors up to and including Live Fire Instructor in Charge are qualified.

Occupational Safety and Health Administration Firefighter Training Standards

29 CFR 1910.156(c)(1)
The employer shall provide training and education for all fire brigade members **commensurate with those duties and functions that fire brigade members are expected to perform.** Such training and education shall be **provided to fire brigade members before they perform fire brigade emergency activities.** Fire brigade leaders and **training instructors shall be provided with training and education which is more comprehensive** than that provided to the general membership of the fire brigade.

29 CFR 1910.156(c)(2)
The employer shall assure that training and education are conducted frequently enough to assure that each member of the fire brigade is able to **perform the member's assigned duties and functions satisfactorily and in a safe manner so as not to endanger fire brigade members or other employees**.

One of the **goals of this recordkeeping rule** is to improve the completeness and accuracy of injury and illness data collected by employers and reported to OSHA. **When workers are**

discouraged from reporting occupational injuries and illnesses, the **information gathered and reported is incomplete and inaccurate.**

The rule includes *three* provisions that are intended to address this issue:

(1) An employer's procedure for reporting work-related injuries and illnesses must be reasonable and **must not deter or discourage employees from reporting**

(2) Employers must inform employees of their **right to report work-related injuries and illnesses FREE FROM RETALIATION**

(3) An employer may not retaliate against employees for reporting work-related injuries or illnesses

Section 11(c) of the OSH Act already prohibits employers from retaliating against employees for reporting work-related injuries or illnesses This rule explicitly incorporates the prohibition against retaliation into **Section 1904.35** of the recordkeeping rule with respect to retaliation against employees for reporting work-related injuries or illnesses (at 29 CFR 1904.35(b)(1)(iv)). **The purpose of this provision is to improve the completeness and accuracy of injury and illness data by allowing OSHA to issue citations to employers who retaliate against their employees** for reporting an injury or illness and thereby discourage or deter accurate reporting of work-related injuries or illnesses.

Why does OSHA address retaliation in this rule? Isn't it already against the law to retaliate against an employee for reporting a workplace injury or illness?

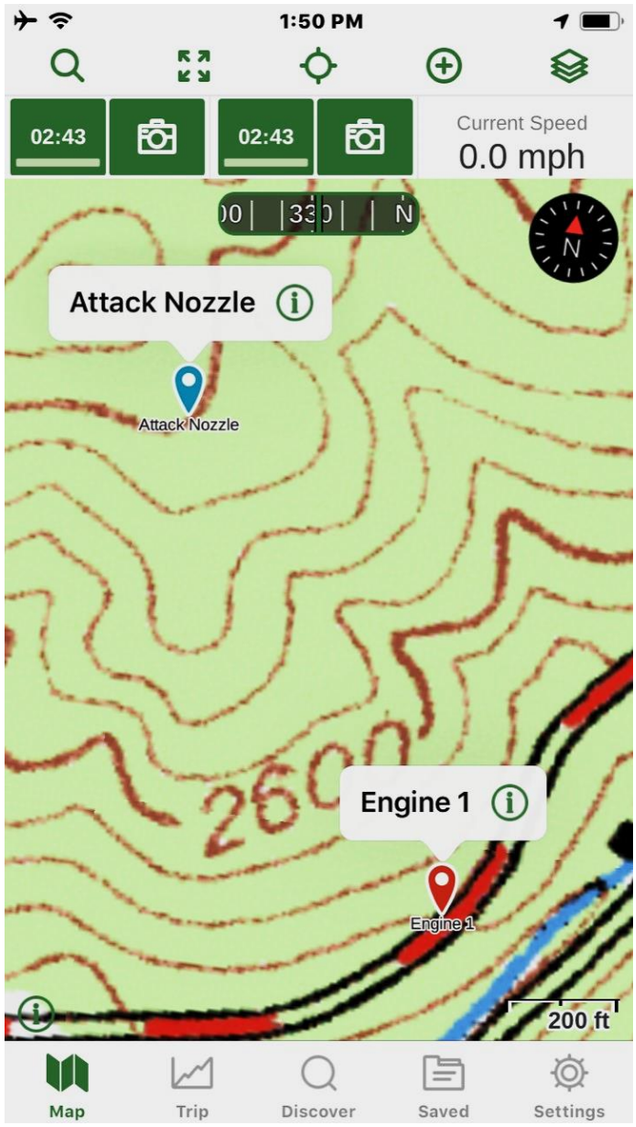
Significant concerns were raised during the comment period that the new electronic reporting requirements in the final rule could lead to increased incentives to take retaliatory action that would discourage workers from reporting their work-related injuries or illnesses. OSHA acknowledges these concerns. Although section 11(c) of the **OSH Act already prohibits any person from DISCHARGING OR OTHERWISE DISCRIMINATING AGAINST AN EMPLOYEE who reports a fatality, injury, or illness,** OSHA may not act under section 11(c) unless an employee files a complaint with OSHA within 30 days of the retaliation. **In contrast, under the final rule, if OSHA finds evidence that an employee has been retaliated against for reporting an injury or illness, OSHA will be able to cite an employer for retaliation EVEN IF THE EMPLOYEE DID NOT FILE A TIMELY 11(C) COMPLAINT.** Often the point of retaliating against an employee who reports an injury or illness is to intimidate both the employee and other workers from reporting. This new rule gives OSHA an important new tool to ensure that employers maintain accurate injury and illness records because it **gives OSHA the ability to protect workers who have been subject to retaliation for reporting work-related injuries or illnesses, even when they cannot or will not speak up for themselves by filing an 11(c) complaint.**

What forms of "retaliation" does this rule prohibit?

The rule prohibits employers from taking adverse action against employees for reporting work-related injuries or illnesses. **Adverse action is action taken by the employer that would discourage a reasonable employee from reporting a work-related illness or injury accurately**. Examples of adverse action include:

- **Discharge**, demotion, or denying a substantial bonus or another significant benefit
- Assigning the employee "points" that could lead to future consequences
- **Demeaning or embarrassing the employee** (for example, requiring an employee who reports an illness or injury to wear a fluorescent orange vest for a week)
- **Threatening to penalize or otherwise discipline an employee for reporting**
- Requiring employees to take a drug test for reporting without a legitimate business reason for doing so.
- Pass **ANY** Wildland Fire "Standard" method training and/or hiring Fire Academy course upon the use of this downloadable spreadsheet at **http://calculator.hydraulicsapp.com**

www.GAIAGPS.com is the best 'support' Android and Apple (iOS) USGS phone app. It provides two (2) sets of topographical contour lines and instant access to the latest Satellite imagery to view current features such as new access roads, exposures, fuel conditions, etc.



The advantage of this support phone app is the elevation is exceptionally accurate, but ONLY if the maps are downloaded before the imminent loss of an internet connection and/or cellular service typical in remote areas. ALWAYS install all maps within your initial attack REGION and immediately upon any out of county assignment while en route. This procedure will ensure you can view the necessary contour lines to determine elevation change accurately and then, therefore, ***ESTIMATE*** (+) HEAD pressure.

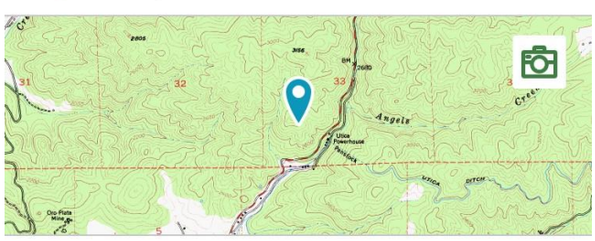
In this example, there are eight (8) forty-foot (40') contour lines between 'Engine 1' and the 'Attack Nozzle' 1,000 feet up the hoselay. The elevation change is 320 feet or (+) 139 PSI HEAD pressure [320' X 0.434 PSI/ft]. This is added to the **Friction Loss (FL)**, **Appliance loss (A)**, and **Nozzle Pressure (NP)** subtotal (predetermined by method and number of laterals operating]. Both the HFT Fire Hydraulics phone apps and Slide-Rule calculate the ***TOTAL*** **Engine Pressure (EP)** in ***REAL-TIME*** and at any point of the hoselay progression.

Below are informational pages for each waypoint that provides the 'legal' coordinates and elevation (above sea level) that verify the change in vertical feet to then confirm the (+) HEAD pressure that both the HFT Fire Hydraulics phone apps and the Slide-Rule calculate.

Engine 1
2/19/20, 7:52:13 PM

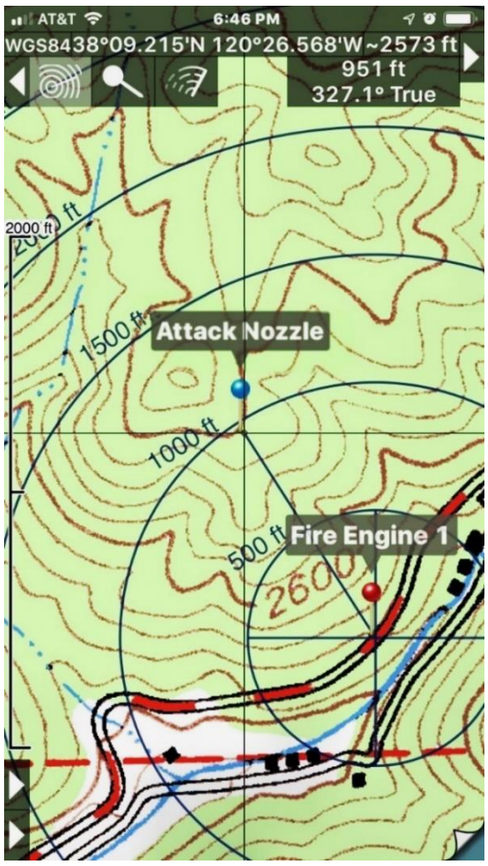
41.45 mi, 163ºS from me
38.15150, -120.44096
Elevation: 2,501 ft

Attack Nozzle
2/19/20, 7:54:42 PM



41.28 mi, 164ºS from me
38.15365, -120.44289
Elevation: 2,818 ft

Please note elevation change (data) from 'Engine 1' at 2,501 feet to the Attack Nozzle at 2,818 feet. These waypoints ESTIMATE 320 feet at (+) 139 PSI HEAD pressure, which shall be compensated at the pump, without exceeding the maximum 400 PSI (as all apparatus are governed) and remain within the internationally accepted formula established 'SAFE' limitations of our equipment. This 400 PSI maximum pressure limits the progression of any hoselay as the required Nozzle Pressure (NP) is then impossible to achieve. To attempt to do so is to endanger our crew members upon direct violation of 29 CFR 1910.156 negligently.



The ***"Topo Maps"*** USGS phone app (left) provides the distance and bearing from your fire apparatus to your crew members (Attack Nozzle) at all times. This is an extremely important tool to further enhance the 24/7 fire resource location accountability requirement that is now mandated by **Section 5** of the ***"Wildfire Management Technology Advancement Act of 2018"*** within the ***"Natural Resources Management Act"*** on 3/12/2019.

However, a distinct **disadvantage** of this app is the inaccurate DECEPTIVE elevation (2,573 ft.) even though the maps are downloaded PRIOR to arriving on the scene. These phone app author(s) accept **NO LIABILITY** of this lack of reliability. It is therefore **NOT** recommended.

Under ALL conditions, **(+) HEAD** pressure is only ever an ESTIMATION at best… and then ONLY upon counting the contour lines **(20' or 40' – KNOW the scale of your map!)** either up or downslope within the USGS (hardcopy or digital) map area, and then only upon the direct communication from fire crew members who report their exact (legal) location accordingly.

In either case, if the phone app fails, the mechanical Hydraulics Slide-Rule and the reference of a hardcopy USGS map of this direct area can also be utilized to determine elevation change. Until then, our ability to accurately estimate Engine Pressure (EP) is severely compromised regardless of equipment or hoselay configuration implemented in the field.

This author emphasizes both phone apps and the Slide-Rule are merely tools and shall be utilized at the same risk as a four-function mathematical calculator, USGS map(s), and notepaper to estimate Engine Pressure (EP) upon the internationally accepted formulas taught in colleges and universities and implemented worldwide for over 140 years. For the first time, ALL driver/operators can now efficiently execute this **'requisite knowledge'** requirement before and during the operation of any wildland fire apparatus, but especially in ***REAL-TIME*** to meet ALL NFPA 1002, Chapter 8, Section 8.2.1 mandates, **including when to STOP.**

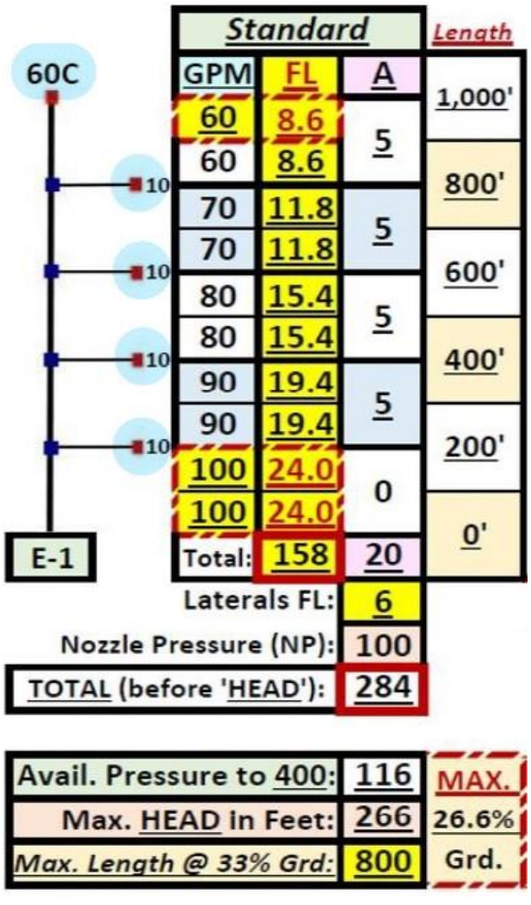
Chapter I: Purpose

We must consider the recommendations of the National Fire Protection Association (NFPA) that OSHA has mandated to ensure firefighter safety as they directly relate to minimum training and education and equipment standards. This ensures wildland firefighter SAFETY is never compromised under any conditions.

NFPA 1002 - Chapter 8 was written to ensure every wildland fire apparatus driver/operator has ***'requisite knowledge'*** in the proper methodology to calculate Engine Pressure (EP) accurately. This is the only manner ***'to produce an effective fire stream… at the rated flow of the nozzle.'*** The instructors must meet NFPA 1941 (JPR) Standards as anything less is in direct violation of all these mandates and have, therefore, created a SEVERE FIREFIGHTER SAFETY RISK. A risk that must always be prevented; and immediately addressed and never compromised to maintain SAFE fireline operations per 29 CFR 1910.156(c)(1) and (2) accordingly.

The purpose of this manuscript is to describe in technical detail the proper use and full application of the world's first-ever ***TOTAL*** Engine Pressure (EP) Wildland Fire Hydraulics Calculator. The mechanical Slide-Rule was created to be stored in the glove box as the **'SAFETY'** (back-up) measure when the phone apps experience battery failure. Not only can they accurately predetermine the most complex variable of this equation:

[Friction Loss (FL) = (GPM/100)^2 * Coefficient * Length/100' (*per affected section*)]



…but both phone apps and the mechanical slide-rule are the first to include ALL four (4) variables. **[Nozzle Pressure (NP), Friction Loss (FL), Appliance Loss (A), and (+) HEAD (H) to** accurately calculate ***TOTAL*** **Engine Pressure (EP)]**. Again, in mere seconds in the field when and where it truly counts! This allows every driver/operator to keep up with the ***REAL-TIME*** adjustments at any point of any wildland fire progressive hoselay configuration [**"*Standard*"** (left), **"*Whaling*"** (original), and the breakthrough **"*HEN-WAY*"** methods] AND when to **STOP** when the 400 PSI maximum Engine Pressure is exceeded.

Now let's take a closer look at the proper methodology and application of the wildland fire version of the hydraulics calculation process. As much as you may have learned, while seated at a desk long ago, this is extremely challenging to accomplish in the field. You know, as a fire apparatus driver/operator, the complexity of this formula to execute in the field is nearly impossible. We have been forced to accept we neither have the time nor resources to compute such a complicated methodology on the fireline when other priorities are in the wake. Especially when personnel has many times already advanced the hoselay up to several lengths, leaving any result obsolete.

We are only left to never catch up with the continual forward progression to ensure proper nozzle pressure is established and maintained at every stage of the hoselay as mandated by law to secure minimum (nozzle pressure) firefighter safety. We can only 'hope' to produce an effective fire stream yet never honestly know when the maximum 400 PSI a Type III engine can produce (EP) has been fully exhausted.

Therefore, many are left confused about why the ISO ratings to qualify a Type III engine is limited to only 1,200' of 1 ½" inch hose and 600' feet of 1" inch hose. The Friction Loss (FL) simply cannot support another inch. As a result, fire personnel can be unknowingly placed in ***DANGER*** when these limits are breached. Ignorance of the direct effect of these irrefutable laws of physics is never an excuse for 100% preventable burn injuries or even death when required Nozzle Pressure (NP) is not even attainable.

The mechanical Slide-Rule and both the Android and iOS phone apps have been solely created to immediately indicate the required Engine Pressure (EP) in ***REAL-TIME*** and **up to and including the point in which ALL FORWARD PROGRESSION SHALL IMMEDIATELY CEASE AND DESIST. If the maximum 400 PSI, a fire engine has been governed to pump (within the limits of our equipment safely) is breached: STOP!**

- This instruction manual is the first to ensure (ALL) **Fire and Emergency Services Instructor(s)** secure the ***Job Performance Requirements (JPRs)*** under **NFPA 1041 – 1.2.2** to train fire apparatus driver/operators the technologies under **NFPA 1002 – 8.2.1** to '***produce an effective fire stream at the rated capacity of the nozzle,'*** without ***'endangering fire brigade members***' upon **29 CFR 1910.156(c)(1) & (2)**

As every fire protection system worldwide [i.e., Hydrant, standpipe, and interior fire sprinkler systems, etc.] has been precalculated and constructed upon this strict, unforgiving internationally accepted formula and methodology, we too must adhere to:

[Friction Loss (FL) = (GPM/100)^2 * Coefficient * Length/100' (*per affected section*)]

…based upon the viscosity of water at normal temperatures and pressures, the proper application/methodology shall never be disregarded nor deviated from upon any (alleged) circumstance EVER. This is further evidenced going back well into the 1800s upon proper application as inspired by the countless fire disasters of that era that lead to the development of the systems relied upon as we almost take for granted today.

Let's compare the ***(deceptive)*** change in **Engine Pressure (EP) at 406 PSI** required for a 900' foot "***Standard***" hoselay configuration with all FOUR (4) 10 GPM 1" laterals operating **(276 PSI)** at 300' feet **HEAD (+130 PSI)** on a 33% Grade to the same configuration advanced only 100' to 1,000' ft. **(284 PSI)** at 320' **HEAD (+139 PSI)** (as illustrated) is **only 17 PSI more to 423 PSI**. Now compare these results when we **advance *only* 100' feet more to 1,100' feet, (FL) increases *(50 PSI at 32%)* to 488 PSI!**

← Standard

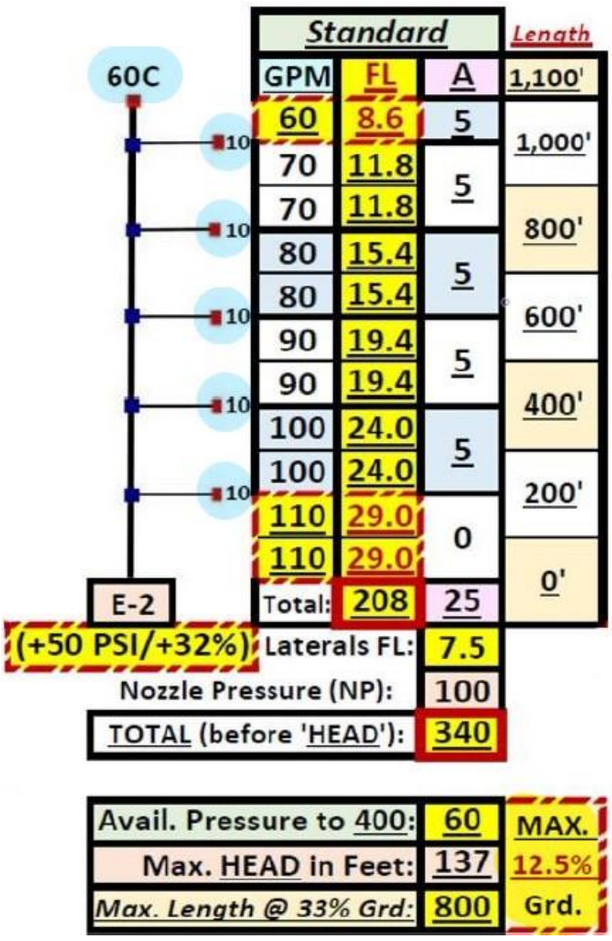
SET OPTIONS	Feet	PSI
HEAD	320	139
Length	1000	RESET
Attack	20/60C	25/75C
Overhaul	10/23C	10/23C
Laterals		
7		
6		
5		
4	423	486
3	413	474
2	395	454
1	372	426
0	345	394

Once 400 PSI is breached, **WHITE LETTERS over RED, YOU SHALL STOP!** Thus, it *appears* only these options are available:

1. Insert the necessary portable booster pump(s) in series at specific locations and proper distances to compensate for all four (4) CALCULATED pressure loss variables **["NP" + "FL" + "A," and (+) "HEAD"]** affecting this end result or...
2. Wait until the total number of laterals for mop-up/overhaul procedures are reduced to the point in which the flow rates, and therefore the total Friction Loss (FL) within each ***affected section*** of hose has diminished, ***BEFORE*** **a CALCULATED** decision can be made to proceed. Yet many still ask,

"How can adding only one (1) 100' foot length of hose be that big of a deal!?!"

Let's look at reality. In the same way, one can increase the height of a triangle drawn on a piece of paper, the point (nozzle) never changes. It is instead the width and resulting surface area at the base that exponentially increases. We are adding a new lateral! That's five and not only four (4)! This exponentially increases the water flow in



the first **AFFECTED SECTION** of two hundred feet (200') of hose supplying water from the engine to the first 1" lateral that is supplying water to that first **10 GPM** overhaul nozzle. Hence in the example provided, we are now flowing **110 GPM at 58 PSI Friction Loss (FL)** to supply the Attack nozzle at **60 GPM** (to protect your crew) ***PLUS* five (5), 10 GPM,** 1" laterals in the first **AFFECTED SECTION** of 1 ½" hose (trunk/attack line). **100 GPM** is then flowing in the next **AFFECTED SECTION** at **48 PSI Friction Loss (FL),** etc., etc. for a total of **340 PSI (NP + FL+ A)** ***BEFORE*** adding **(+) HEAD pressure!**

This leaves only **60 PSI** (to 400 PSI Max) or **137' feet of HEAD pressure** that **limits the 1,100' feet hoselay to a 12.5% Grade!**

Any **SAFETY** concerns to **ONLY pump LESS THAN one-half (<½) the 26.6% Grade, and therefore, NOT *'produce an effective fire stream* at the *rated flow of the nozzle*?'**

The driver/operator is mandated *(by law and common sense)* to cease *ALL* forward progression *BEFORE* the evidenced Maximum 400 PSI Engine Pressure (EP) is exceeded! If not, the fire crew is irresponsibly, immediately placed in ***GRAVE DANGER*** upon evidenced **GROSS NEGLIGENCE *upon incompetence!***

Yet many ask, ***"When am I, or am I ever required to install a booster pump to support the rest of the hoselay?"***

Hence, the invention of ***"Hoffmann's Extraordinary New-Way" ('HEN-WAY')*** wildland fire hoselay deployment system/ configuration described in **Chapter 2** is to address this very unforgiving issue as never before in Fire Service history upon the inquiry:

← Standard

SET OPTIONS	Feet	PSI
HEAD	340	148
Length	1100	RESET
Attack	20/60C	25/75C
Overhaul	10/23C	10/23C
Laterals		
7		
6		
5	488	563
4	477	550
3	457	528
2	431	497
1	401	461
0	368	422

"Is not Friction Loss a direct mathematical function of Gallons Per Minute?"

Both the Android and iOS phone apps and the mechanical slide-rule calculate minimum Engine Pressure (EP) with the total number of laterals operating. A second list to indicate minimum '**OVERHAUL**' Engine Pressures (EP) when containment is ***(believed to be)*** 'satisfactorily' achieved. This significantly reduces wear and tear on equipment and resources and still warns (color-coding remains) when **'ATTACK'** pressure may be required.

By briefly reducing a 20/60 GPM or 25/75 GPM nozzle from **'ATTACK'** mode at 60 or 75 GPM to the '**OVERHAUL**' operations at 20 or 25 GPM, the Total Engine Pressure must be re-calculated. The gallons per minute (GPM) is reduced to one-third (1/3rd) and the Friction Loss (FL) component is reduced to 1/9th. A whole section of this book is dedicated to assisting the reader to understand this side of the overall Engine Pressure (EP) calculation process more fully.

Hence the (legal) need of both Phone Apps and the Slide-Rule to accurately calculate Engine Pressure (EP) for the SAFETY of your crew (your greatest resource). The are counting on you to meet and exceed **OSHA – 29 CFR 1910.156(c)(1) and (2)** upon the guidelines of **NFPA 1002 and NFPA 1041.** These Laws of Physics are instructed at every 'reputable' fire training/hiring academy, college, and university worldwide for more than a century.

May I inquire, ***"If every Type III engine is governed to produce a maximum of 400 PSI, yet your (desired) hoselay configuration requires far more than what is possible to support, would you not agree you are in direct violation of OSHA 's General Duty Clause: Section 5(a)(1) if you make such a GROSSLY NEGLIGENT attempt to perform!?!"***

This is the exact reason why the certified specifications of any "Type 3" Wildland Fire Engine has always only ever required twelve (12) 100-foot lengths of 1 ½" hose and only six (6) 100-foot lengths of 1" hose! 400 PSI can only support a typical 900 to 1,000-foot hoselay at a moderate slope/grade; with a few extra lengths of 1 ½" and 1" hose as spares onboard in the inevitable event that necessary replacement is necessary due to hose failure upon dragging every inch up steep, rough terrain. Learn how to prevent this issue at: ***www.HoseRoller.net***

Since this standard was established many decades ago at the inception that fire apparatus are classified to meet ISO requirements, there's never been a need to increase this financial investment. Why would we budget these fire apparatus with more hose than what the pump can SAFELY pressurize even if it results in the inability to support our fireline personnel SAFELY in the performance of their job classification(s)?

To summarize, there are essentially only two (2) modes of operation:

- **Initial Attack,** which has been described in all previous references made herein.
- **Mop-up/Overhaul operations** and its effect on TOTAL Engine Pressure (EP) upon significantly reduced water flow rates that results in reduced Friction Loss (FL).

An entire chapter is dedicated to addressing this need in which **the color-coding for each result is NOT changed from 'ATTACK' mode to emphasize the *WARNING*** to the operator. If ATTACK mode is required to contain an unanticipated ESCAPE (slop-over) or severe BLOW-UP, communication to all personnel assigned on a given hoselay needs to be maintained to ensure all non-related overhaul nozzles can be temporarily suspended. Thus ensuring ALL nozzle(s) in the 'emergency' affected area are used to support those operations more effectively and much more SAFELY for all crew members.

Please also read my article (attached) ***"Fire Hose Coil 'Bundle' Technology - Garden Hose Simplicity"*** for the most efficient hose deployment methodology that NEVER kinks under any circumstance EVER. It not only reduces the overall required effort to deploy any fire hose as much as 1/3 (per 100' FULLY deployed), but 200' feet can be fully charged in seconds in a footprint/confined space with less than 16 square feet. Additionally, you can also learn the impossible! How to fully charge a 2 ½" X 200' 'Blitz Line' within 10' of the rear of your apparatus… and be fully deployed… around right-angle turns… in which the nozzle person NEVER drags more than 25' of hose to the full length of the hose! That's CRAZY!

Other incredible enhancements in technology such as the Automatic Vehicle Location (AVL) equipment can confirm resource situational awareness 24/7/365. When used in conjunction with the suggested Geographical Positioning System (GPS) available on any smartphone, even our personnel are immediately displayed on any U.S.G.S. map (i.e. ***"GAIA Maps"***). This further assists a driver/operator to better determine estimated HEAD pressure (loss or gain) to calculate accurate Engine Pressure (EP). Done in ***REAL-TIME*** upon the continuous radio-communicated location of all fire-line personnel who check-in with their supervisor regarding lateral/overhaul operation status as required.

As a result, both phone apps perform outstandingly as secondary back-up devices to ensure **Section 5** of the ***"Wildfire Management Technology Advancement Act of 2018"*** that mandates ALL fire resources, fire apparatus, and equipment, but especially personnel assigned to any Federal Type 1 incident shall be immediately and continuously monitored to determine exact location and status at all times is completely supported and therefore fulfilled as well!

Chapter II: The "HEN-WAY" Hose Lay Deployment Methodology

The internationally accepted formula that has been implemented to install every water delivery system [Hydrant, Standpipe, Hose Cabinet, Sprinkler, Irrigation, etc.] on the planet for the past 115 years is:

[Friction Loss (FL) = (GPM/100)^2 * Coefficient * Length/100']

[*within each and every individually (GPM) affected section*]

…and the formula to calculate Wildland Fire Engine Pump Pressure (EP) is:

[Nozzle Pressure (NP) (+) *GRAND TOTAL* Friction Loss (FL) [*subtotal* of each 'OVERHAUL' Lateral as they *(GPM) affect* the *subtotal* of each *section* of 'ATTACK' line] (+) Appliance Loss (A) and (+) or minus (-) HEAD (H) (=) Engine Pressure (≤400 PSI)]

The ***"Standard"*** method at 60 GPM ('ATTACK') with 10 GPM laterals every 200' feet can only pump 1,000' feet at 26.6% Grade. But if only one (1) DECEPTIVELY INNOCENT length of hose is added **a FIFTH (5th) LATERAL that causes a 110 GPM to flow through in the first 200' at the engine causes a *52 PSI or 32% INCREASE IN PUMP PRESSURE* to support 1,100'!** This configuration now requires 340 PSI! That's only 60 PSI until breaching the maximum 400 PSI, leaving only 138 feet in (±) HEAD on a **maximum UNREALISTIC 12.6% Grade**.

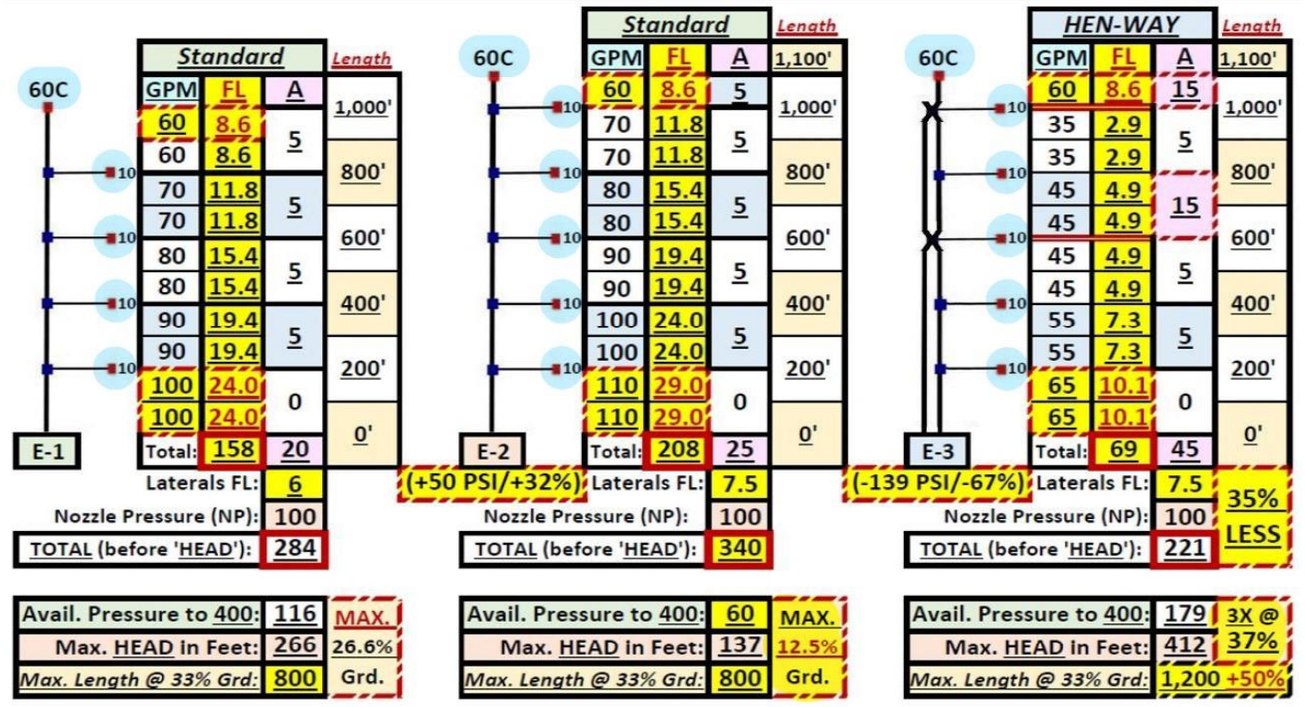
At 1,200' the driver/operator is required to compensate for the Friction Loss of only one (1) more length at 349 PSI. This leaves only 51 PSI until breaching 400 PSI or only 118 feet in (±) HEAD on a maximum 9.7% Grade before ENDANGERING YOUR CREW with almost ZERO Nozzle Pressure (NP) if the slope remains at 26% or more!

But at 1,300' feet, all figures again exponentially increase now that **SIX (6) 10 GPM LATERALS at 416 PSI is required!** That is a **FULL 16 PSI OVER THE MAXIMUM 400 PSI** BEFORE (±) HEAD PRESSURE IS EVEN achieved(!) … if LESS THAN A ZERO PERCENT GRADE EXISTS (-2.6%). Even on **FLAT GROUND, THIS IS NOT POSSIBLE!**

And some forever scratch their head wondering why in the world would a Type III Wildland Engine be complemented with less than 1,200' feet of hose… EVER!?! Especially when they are the very ones who have done the (different methodology) calculations in the field **upon being INSTRUCTED (severely mislead) that 2,000' feet is possible!** As a result, many have ***NEGLIGENTLY placed their crews in GRAVE DANGER!!!***

It is a FACT that each (10 GPM) LATERAL incrementally increases the overall GPM within each affected section of hose PRIOR in the hose lay and most significantly at the source where the hose attaches at the pump. Some have misleadingly been taught to BELIEVE it only affects each length of hose leading up to the end.

The theory, use, and application of the ***"HEN-WAY" ["Hoffmann's Extraordinary New – WAY"]*** wildland fire hoselay configuration/methodology exponentially exceeds every evidenced inherent limitation of the ***"Standard"*** method. A methodology never witnessed in Fire Service history!



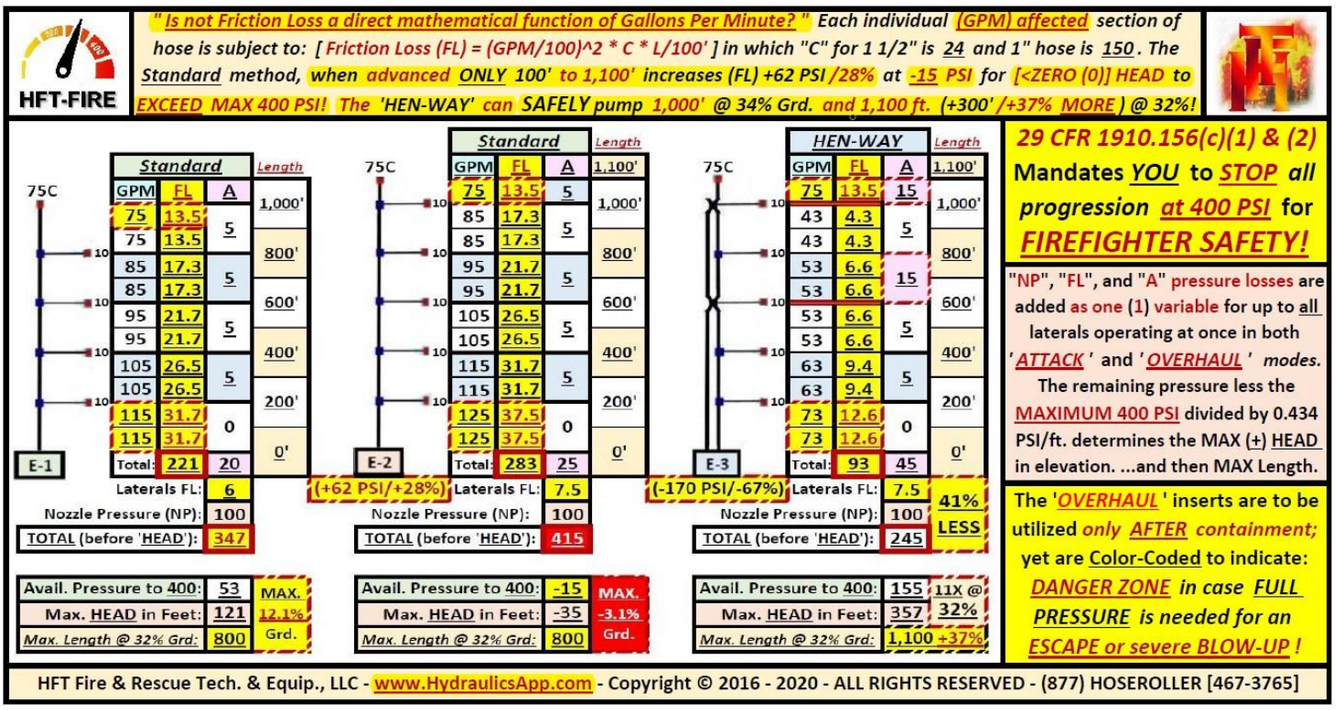
Upon flowing 60 GPM at the 'ATTACK' nozzle with 10 GPM laterals every 200' feet… at 600' feet and again at 1,000' feet, specific equipment is placed in the progressive hoselay to establish flow (supply) through dual (2) hose lines and not just one (1). Dual hose lines, as suggested as necessary by the USFS in Fig. 21 on Page 20 of their bible ***(Basic Hydraulics - An Introduction to Fire Streams)***, significantly reduces the Friction Loss (FL) component by as much as 75% upon the lengths affected.

The ***"Standard"*** method is limited to 800' feet on a 33% Grade… yet the ***"HEN-WAY"*** can SAFELY pump 1,200' feet at the same slope! That's a **50% increase in hoselay length** at more than **THREE TIMES(3X) the 10% Grade.** The ***"Standard"*** can only begin to attempt this… thus placing the crew members in DANGER with evidenced inadequate Nozzle Pressure (NP) above a 10% slope.

The HEN-WAY eliminates the need to hand-carry an extremely heavy, essentially ineffective, and expensive PORTABLE PUMP over two (2) football field lengths upslope. Not to mention through heavy brush and timber (and back!) just to maintain proper nozzle pressure for a couple more hundred feet to attempt to secure firefighter SAFETY!

In the same manner before the invention of LDH was used for larger municipal fires; the advantage of establishing dual lines is that this procedure significantly reduces the total GPM through each length to about half. Roughly ½ GPM times (X) ½ GPM equals ¼ the TOTAL Friction Loss (FL) component. Meaning this fraction of the GPM squared reduces the total friction loss as much as 75%! Hence the results we begin to realize below.

More importantly, in the high country where slopes are horrendously steep, and the USFS/BLM/NPS refuses to GSA contract a nozzle of **no less than 75 GPM for firefighter *SAFETY*.** The ***"HEN-WAY"*** allows personnel to ***SAFELY*** pump a **1,000' hoselay at a 34% Grade** with the same four (4) 10 GPM **'OVERHAUL'** laterals operating; and reduces the **Friction Loss (FL) component 170 PSI at 67% LESS** than the Standard method when advancing only 100' to **1,100' on a 32% Grade** …as it can support a **1,200' hoselay at a 27% Grade** with **25% more water than a 60 GPM nozzle to significantly increase firefighter SAFETY!**



The ***"Standard"*** method at 75 GPM ('ATTACK') can only begin to pump **1,000' feet at 12.1% Grade**, and can ***NEVER*** pump an **1,100' hoselay that requires 415 PSI!** That is **15 PSI OVER the maximum 400 PSI BEFORE (+) HEAD can even be considered!** … in that if LESS THAN A ZERO (0%) PERCENT GRADE EXISTS **(-3.1%), FLAT GROUND IS STILL NOT EVEN POSSIBLE to begin to protect your crew… let alone provide them the PROPERLY CALCULATED Nozzle Pressure (NP) to do their job!**

This incredible breakthrough of establishing dual lines is nothing new. The Federal agencies introduced this method in 1978 with the example to reach a small fire 3,000' from the engine. What I am introducing here has never before been achieved in Fire

Service history! All just by merely adjusting the application of a few specific pieces of equipment differently from multiple Type 3 engines that would already be on-scene yet without the weight of an expensive, ineffective Portable Pump upon the procedure to:

1. Attach two (2) 1 ½" hose lines at the engine; one for 'ATTACK' and a second for 'SUPPLY' line to be laid parallel and DRY/EMPTY waiting to be charged later.

2. Extend both while fighting the fire in that at 600' feet in that the 1,200' ft. of 1 ½" hose complement of the first Type III engine at the scene will be exhausted.

3. Clamp the 'ATTACK' hose line; and remove the nozzle to expose the 1 ½" male coupling.

4. Attach two (2) 1 ½" double females to each exposed 1 ½" male. The first on the primary 'ATTACK' hose line and the second to the 1 ½" 'SUPPLY' line.

5. Connect each double female to each male of a reversed 1 ½"F X 1 ½"M (2) Gated-Wye

6. Connect an 1 ½"M X 1 ½"M double male to the 1 ½"F of the Gated Wye to re-reverse the threads back to a 'forward lay' direction

7. Connect an 1 ½" X 1"M 'Tee' (water-thief) to supply the next 1" X 100' foot 'OVERHAUL' lateral

8. Connect the last 1 ½" Gated-Wye now pointed in the correct direction to…

9. Connect both an 'ATTACK' hose line and a DRY/EMPTY 'SUPPLY' hose line to each discharge on the 1 ½" Gated-Wye in the same way as you did to connect both lines to the engine at the first 100' of the 'ATTACK' as performed in Step #1 above.

10. Replace the nozzle and open the valve to charge only the 'ATTACK' line. (Length on the side closest to the fire line).

11. Advance both lines as described in Step #2 above upon laying the second 'SUPPLY' hose line DRY/EMPTY but protected on the outside the fireline of Step #10.

12. Progress four (4) FULL dual lengths as you fight fire with the 1 ½" 'ATTACK' as you again lay 400' feet of DRY/EMPTY 'SUPPLY' hose lines until reaching 1,000' feet.

13. REPEAT step #3 and all steps following in the same manner, but taking note that if you're steeper territory than a 20% Grade, only the ATTACK line is attached and advanced from here.

Continue progression 100' feet at a time until all ENGINE PRESSURE (EP) is calculated to meet but NEVER breach 400 PSI. It is critical to keep in direct communication with ALL crews to verify the total number of laterals operating and the

accurate estimated (+) HEAD of the highest elevation nozzle using the latest USGS maps (phone app or hardcopy) within the hoselay accordingly.

You cannot get behind the wheel as a Driver/Operator and be expected to pump a hoselay SAFELY without the confirmed REQUISITE knowledge of hydraulics as required under NFPA 1002. Only this will meet the 29 CFR 1910.156 mandates. If members of your crew suffer burn injuries or even death, this very technology and equipment never before available can be used as evidence against you. An attorney can find you liable for any evidenced GROSS NEGLIGENCE upon alleged severe INCOMPETENCE for any procedure(s) in direct violation of the laws of physics as articulated herein!

Unfortunately, there are many wildland fire apparatus driver/operators who have spoken to me who ***BELIEVE*** **and** ***BOASTED*** **that they have pumped a 2,000' foot or more hoselay as forever possible. All based on their** ***BELIEF*** **created upon a mathematical equation that (allegedly proves), only 331 PSI ENGINE PRESSURE is required BEFORE (+) HEAD in that they do not even realize they are limited to a 7.9% Grade!**

Yet in fact, **727 PSI** is **(mathematically PROVEN)** required **BEFORE the (+) HEAD** is even considered! That is **327 PSI above the maximum 400 PSI what a Type III engine is** capable of pumping to ***PROTECT*** our crews and equipment! AND yet this mathematical calculated application ***ERROR*** is **396 PSI LESS than the ACTUAL! Which is nearly the *TOTAL* MAXIMUM pressure, in and of itself, that an engine is governed to STOP for SAFETY!**

Did someone lose site of the ***Hazen-Williams formula*** methodology invented in 1903 that has been used in every water delivery system designed, created, and utilized on the globe today!?! What about the **National Wildfire Coordinating Group (NWCG)** and its clear directives upon their instruction in Section 3.3 Friction Loss as it applies to Section 3.4 Engine Pressure? It is not clear that at any time, if less than the minimum required Engine Pressure (EP) is produced, a critical concern of **Occupational Health and Safety** arises as strictly enforced by and within the jurisdiction of ***OSHA Section 5(a)(1) - General Duty Clause!?!***

How alarmed should the common layperson be when he/she discovers hundreds have been purposely misled and trained and hired to MIScalculate resulting Nozzle Pressure (NP) that is critically important to save their lives and property? What do you *think* a jury of your peers might believe upon learning these specific Laws of Physics and Standard Operating Procedures (SOP's) executed throughout the history of the fire service have been this severely disregarded? Would you not consider this a direct

violation of the content of literally every 'Hydraulics' book ever published? Conversely, is there any reason you would distrust the ***Hazen-Williams formula*** that has established merit for more than a century of direct application and implementation internationally since 1903?

Hence the reliance on what most of us count-on as '*our*' rule of thumb:

'With one arm fully extended, quickly increase the fire engine pump pressure until the nozzle-person rises a full thumbnail off the ground. Then and only then, back the throttle off half-a-turn. DONE!' 😊

Perhaps it is time we can choose to live in the 21st century? …to accept the true purpose and application and of this technology and utilize these incredible resources for the SAFETY of our personnel. Never before has TOTAL wildland fire-engine pump pressure been accurately estimated in mere seconds! Especially when your crews are out-of-site and many (unknown?) hose lengths up the fireline when the demonstrated performance of that pump operator is so heavily relied upon to at least be close to what they communicate they need.

More will be written in all these areas, including the countless advantages of the single greatest pre-connect hose load configuration that functions impeccably at EVERY INCIDENT type and allows immediate deployment with ZERO kinks every time! A configuration that even fully charges within 10 feet of the engine… in most limited or confined spaces… and delivers water at ALL phases of the deployment process as demonstrated on the YouTube video at **http://HoseRoller.net** and **http://BurnOver.HFTFire.com**

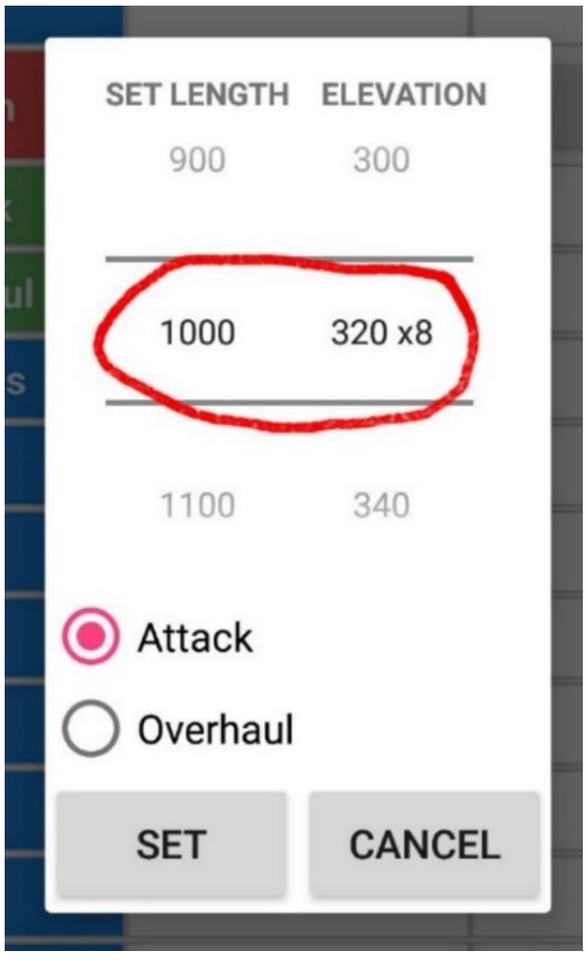
Just ask Texas A & M University what methodology they have been teaching since I released my copyright to this very video in 2006. Three (3) firefighters could deploy three (3) pre-connects within ten (10') feet of the engine, each flowing 200 GPM in a matter of SECONDS(!) …a deployment system at 600 GPM utilizing onboard water for 50 seconds directed more accurately than air support.

Lastly, learn how this 59-year-old man can fully charge 200 feet of 2 ½" hose within 10 feet of the rear of an engine… with NO kinks ever… flowing 500 GPM through an 18" Combination 'play-pipe'… and deploy this fully charged hose in any direction around right-angle and 180 degree turns until the FULL 200 feet hose has been FULLY deployed and yet NEVER drag the hose! **Please go to: http://NoDragHoseLoad.com**

Chapter III: The Phone Apps

The ***'www.GAIAGPS.com'*** phone app is used to pre-download literally any USGS map across the entire North American continent and beyond for an annual fee that is currently waived for First Responders at a ***$19.99/yr VALUE!*** The "HEAD" pressure component of the calculation process is then determined by simply counting the number of contour lines. The given elevation change (either 20' interval isobars at lower, less steep areas… and 40' interval isobars at higher, and steeper terrain areas) is measured between the fire engine and the last confirmed (communicated location) or expected peak elevation 'waypoint' of our personnel at the highest nozzle anywhere within the hoselay.

Upon activating the "***HFT-Fire***" **Wildland Fire Hydraulics Engine Pressure calculator** phone app, the "SET OPTIONS" button (at the upper left of the display page with red lettering on gray background) is then tapped to be transported to a second page to enter only the hoselay length and positive (+) or negative (-) elevation change accordingly. Simply scroll up to enter the current length of the hoselay indicated in 100' hose lengths as verified by the approximate distance between the engine and last indicated waypoint as communicated by personnel. Do the same to calculate HEAD (H) by scrolling up or down to select the calculated elevation change per the contour lines found on the ***'GAIA Maps'*** phone app display.



- It is critical to keep track of the actual number of lengths of 'Attack-Line/'Trunk-Line' to accurately calculate the TOTAL of all four (4) variables [(NP) + (FL) + (A) before adjusting for (+) or (-) Head (H)] to determine accurate Engine Pressure (EP) in ***REAL-TIME*** accordingly.

Next, the elevation is entered upon scrolling up (for uphill) upon the number of isobars counted up for positive (+) **HEAD** pressure ***(LOSS)*** and simply scrolling down (for downhill) for negative (-) **HEAD** pressure ***(GAIN)*** in increments of 20' intervals indicated as:

- "0", then "(+) **20**", then "(+) **40 x1**" (to indicate one (1) contour line at (+) 40') then "(+) **60**", then "(+) **80 x2**" (to indicate **two (2)** contour lines at (+) 80') then "(+) **100**", then "(+) **120 x3**" (to indicate **three (3)** contour lines at (+) 120'), etc. …up to "(+) **520 x13**" (to indicate **thirteen (13)** contour lines at (+) 520') in that the elevation change in feet is followed by "**x**" (times) the numeral portion"**Y**" that indicates the total number of **40' elevation intervals** in order to make this phone app a little more 'user-friendly' and therefore easier to accurately determine each Engine Pressure (EP) accordingly.

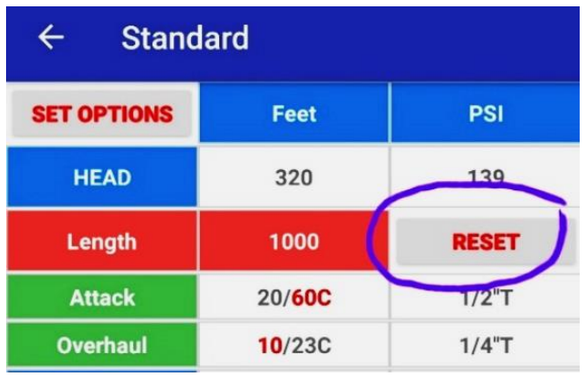
Upon selecting the **"ATTACK"** and **"SET"** keys, the phone app instantly calculates FULL Engine Pressure (EP). This is based on all four (4) variables listed above as presented on the first page that shows two (2) columns of Engine Pressure (EP) results per the nozzles selected in the field. The driver/operator then reads down the appropriate column by nozzle **FLOW [GPM as "20/60C" or 25/75C]** and then reads across upon the current number of laterals (row) operating at **10/25C GPM** for mop-up/overhaul purposes in ***REAL-TIME*** at that particular length of progression of the wildland hoselay accordingly.

← Standard

SET OPTIONS	Feet	PSI
HEAD	320	139
Length	1000	RESET
Attack	20/60C	25/75C
Overhaul	10/23C	10/23C
Laterals		
7		
6		
5		
4	423	486
3	413	474
2	395	454
1	372	426
0	345	394

TOTAL **Engine Pressure (EP)** is calculated in each respective column in that all numeric values between 0 and 299 remain **bold black on a white background**. When the Engine Pressure (EP) reaches above 300 PSI and up to and including 399, the numeric characters become **bold red on a yellow background** **to indicate you**

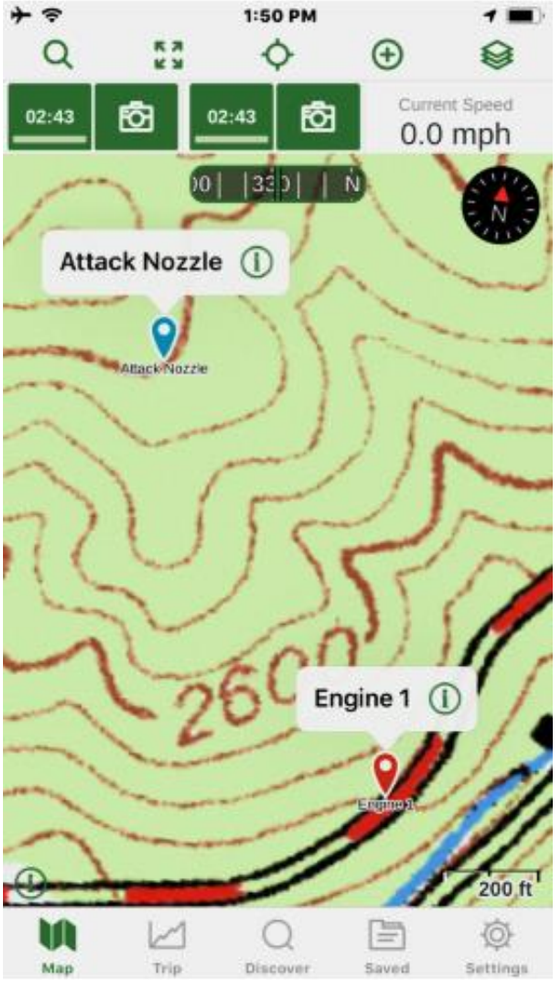
are quickly approaching the maximum 400 PSI that your engine will produce. But when the calculated Engine Pressure (EP) exceeds 400 PSI, the numeral characters become **bold white on a red background** to indicate ***OSHA's General Duty Clause 5(a)(1)*** to ensure firefighter safety has been violated. The evidenced **required Nozzle Pressure (NP) is no longer possible.**

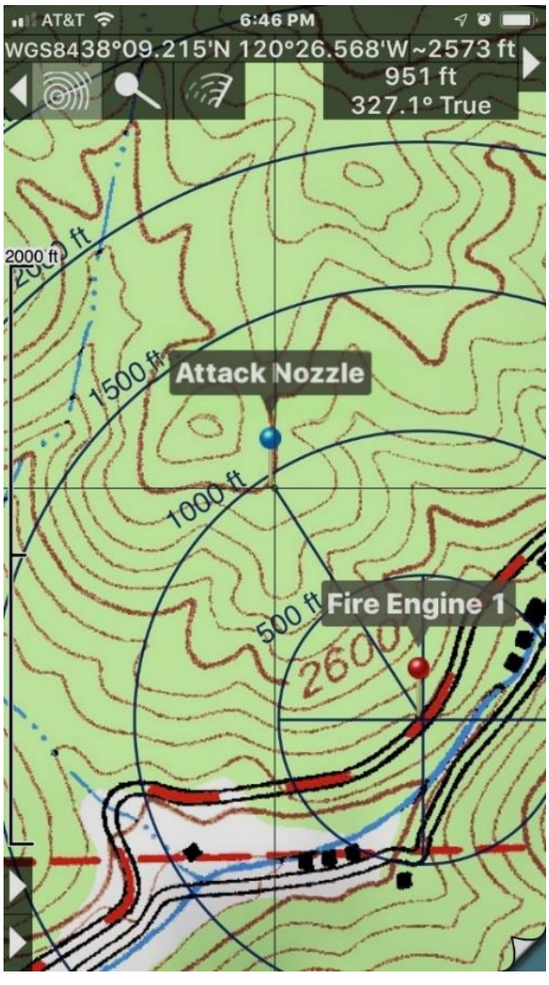


To restore the phone app to its default settings, select "**RESET**" to reset the Engine Pressure (EP) calculator to all results to zero (0)] and begin the process as when first arriving on the scene.

Only two (2) options are available to the Driver/Operator. The first, strategically position portable booster pump(s), or fire apparatus that can be safely driven upslope, in series to increase the minimum Nozzle Pressure as necessary. Secondly, the operator can wait for the number of laterals in use is reduced upon completion of mop-up/overhaul operations to then reduce flow (GPM) and, therefore, Friction Loss (FL) accordingly.

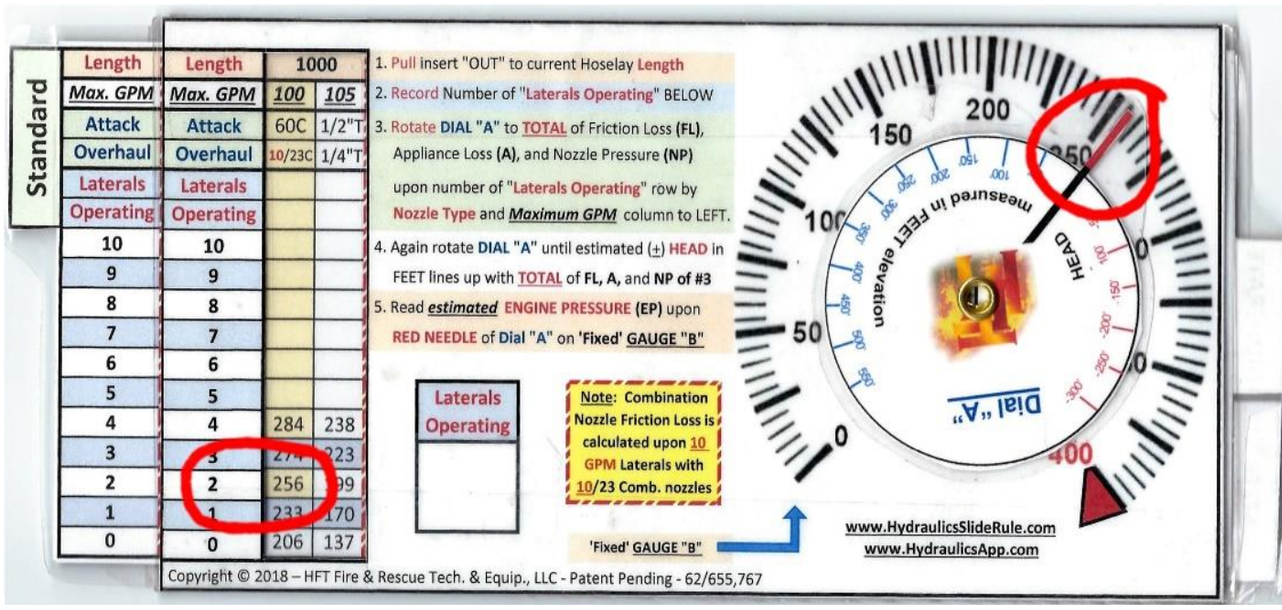
All examples within this manuscript are based upon a typical scenario found at the 2,600' elevation in the central Sierra Nevada Mountain range foothills below.





Chapter IV: The Mechanical Slide-Rule

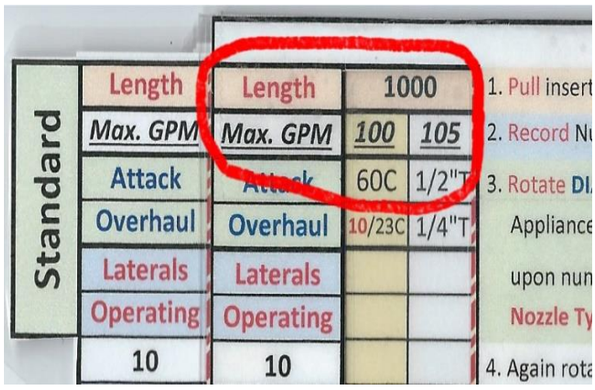
To demonstrate the process of the HFT Fire Hydraulics Slide-Rule, we will use the example on Page 7 and 8 upon a **1,000' "Standard" 1 ½" hoselay with a 20/60 GPM 'Attack' combination nozzle.** We will compute for **ONLY two (2) of four (4) laterals operating** upon utilizing **10/23 GPM combination nozzles; eight (8) USGS map contour lines at 40' each;** to determine **320' of elevation** and therefore **139 PSI "HEAD"** pressure loss.

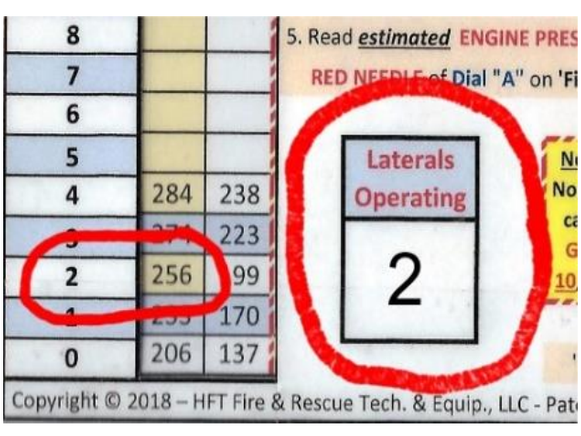


It is recommended this tool shall be maintained within each fire apparatus, as a back-up to the phone app, but with its own set of instructions in that the driver/operator shall:

1. **"Select (insert) mode: ATTACK vs OVERHAUL"**
2. **"Pull insert "OUT" to current Hoselay Length"**

   Pull out the appropriate insert **["*Standard*" or "*HEN-WAY*"]** to the actual hoselay length indicated in 100' hose length intervals. Both columns are listed by nozzle type ["20/60C" or **25/75C**] as the insert is extended until the hose lay length is clearly visible within the laminated window as above.





3. **"Rotate DIAL "A" to (sub) *TOTAL* of Nozzle Pressure (NP) + Friction Loss (FL) + Appliance Loss (A) upon number of "Laterals" operating (row) by Nozzle Flow (20/60C or 25/75C GPM) column to LEFT."**

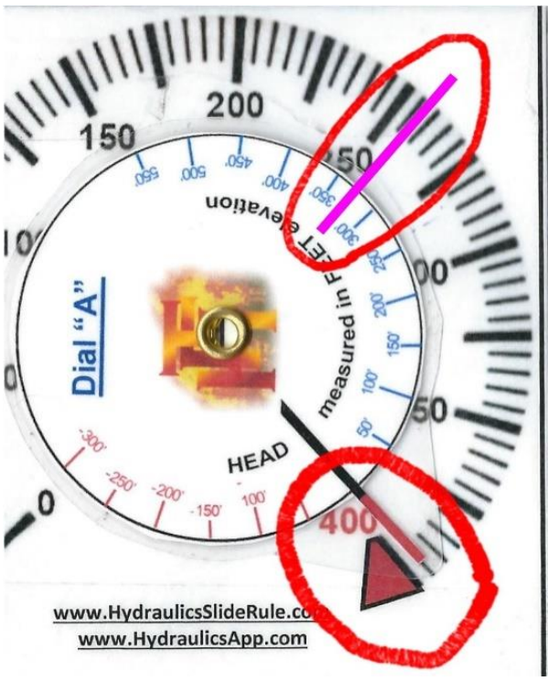
The accurate calculated SUBTOTAL of (NP) +

(FL) + (A) is then determined upon reading down the appropriate column by nozzle type and across by the current number of laterals operating at that particular phase of the hoselay evolution. The **Dial 'A'** setting, which represents a Type III engine pump pressure gauge that reads from "0" to "400" PSI, is then manually **rotated** until the red/black pressure needle lines up with this calculated SUBTOTAL of (NP) + (FL) + (A) per the number of laterals in step #2**.**

[Example **256 PSI for two (2) laterals operating** in the 1,000' ft. hoselay (as USGS map illustrated herein)].

← Standard		
SET OPTIONS	**Feet**	**PSI**
HEAD	320	139
Length	1000	RESET
Attack	20/60C	25/75C
Overhaul	10/23C	10/23C
Laterals		
7		
6		
5		
4	423	486
3	413	474
2	395	454
1	372	426
0	345	394

4. "Again **rotate Dial "A"** until estimated (+) **HEAD** in FEET lines up with (sub) **TOTAL of NP + FL + A of #3"** Add (+) or subtract (-) calculated (or estimated) (±) HEAD Pressure at 0.434 PSI per foot or (±) 43.4 PSI per (±) 100 feet of elevation change. Hence, the preloaded U.S.G.S. maps at "***www.GAIAGPS.com***" are such a powerful and necessary tool in the field.



a. LEFT **(counter-clockwise)** of the red/black pressure needle is **"BLUE"** in measured increments of approx. ***22 PSI positive* (+) HEAD (H)** pressure per 50' feet ***increased*** elevation.

b. RIGHT **(clockwise)** of the red/black pressure needle is **"RED"** in measured increments of approximately ***22 PSI negative* (-) HEAD (H)** pressure per 50' feet in ***decreased*** elevation.

c. The final step to determine accurate Engine Pressure (EP) per the **internationally recognized calculation method** is to again **rotate Dial 'A'** until the estimated elevation **[(+) Blue** for upslope; **(-) Red** for downslope] lines up with the first subtotal result from item #3.

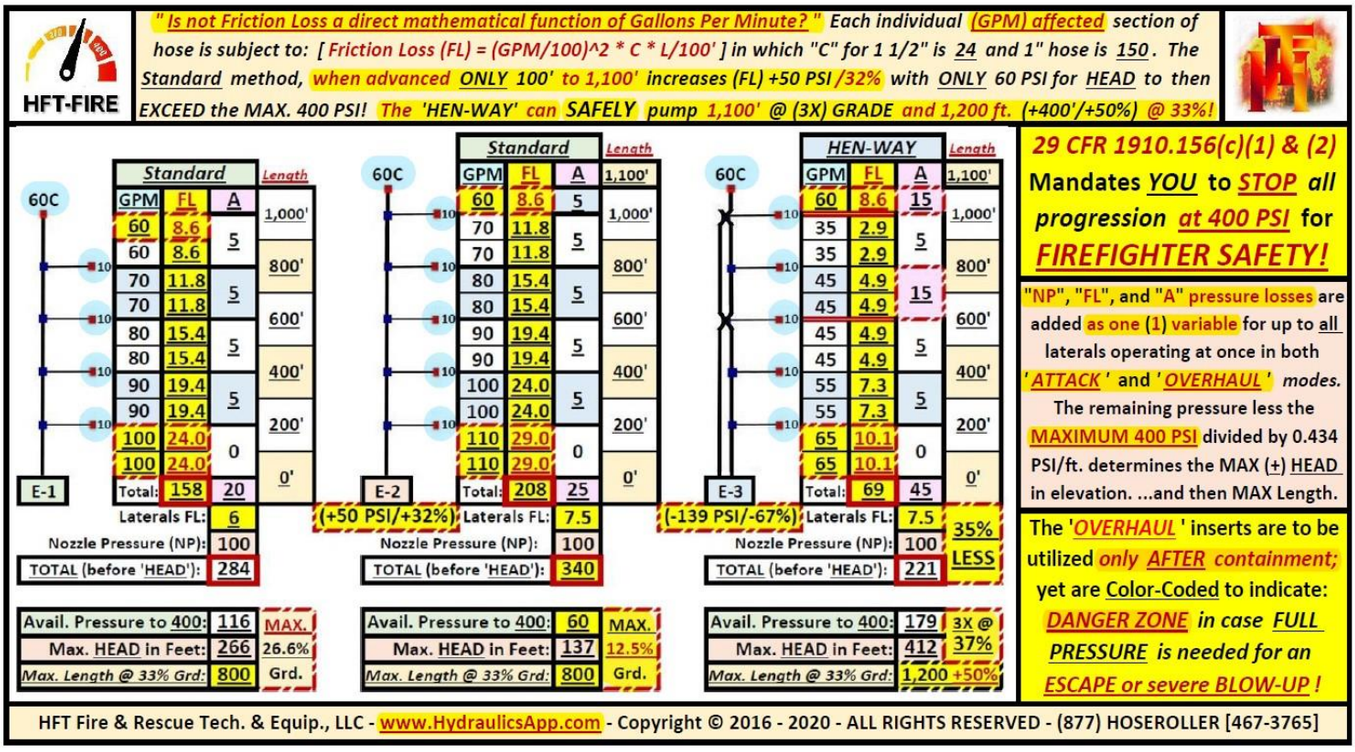
5. **Read estimated ENGINE PRESSURE (EP) upon RED NEEDLE of Dial "A" on 'Fixed' GAUGE "B"**: Simply read the resulting accurately calculated Engine Pressure (EP) as indicated upon this final position of the red needle on the pressure gauge

accordingly. Thus **"NP" + "FL" + "A" *[as one (1) predetermined subtotal result]* + "H" = Engine Pressure (EP) [Example 395 PSI Engine Pressure upon two (2) laterals operating]**

In other words, we just measured with a micrometer… marked it with chalk… and cut it with a chainsaw! We can now confirm this Engine Pressure (EP) upon verifying the same entries on the Phone App on page 14 above arrive at the result.

Never before has this technology been available to meet this SAFETY standard, but especially in mere seconds to maintain PROPER minimum Engine Pressure upon every length of hose in progression in ***REAL-TIME! …BUT ESPECIALLY WHEN TO STOP!!!***

Slide-Rule Reverse Side – "Standard" at 1000' and 1,100', then the "HEN-WAY" 1,100'



The backside of the slide rule shows not only how each section of a hoselay is directly affected upon accurately measured and anticipated water-flow rates per the number of laterals operating, but it also illustrates every dynamic of this mathematical process. This further supports a driver/operator's education of what he/she must be accountable and respect to be given the responsibility of each fireline crew member's safety. Sufficient Engine Pressure (EP) and resulting SAFE Nozzle Pressure (NP) can now be managed accordingly.

Please take this opportunity to review each of the highlighted details and directives to become fully aware of why it is so critical we pump the calculated Engine Pressure we pump. Until we grasp full knowledge, we will truly never understand why we must **CEASE and DESIST** all forward action when Laws of Physics PROVE we can proceed no more. It cannot be emphasized enough the liability each driver/operator is subjected to if he/she does not perform to these minimum NFPA training standards and procedures as articulated herein.

Chapter V: Mop-Up/Overhaul mode

As an added benefit to both the iOS and Android Phone Apps and the mechanical Slide-Rule, the author has added the calculation process to determine Engine Pressure (EP) during **"Mop-Up"** or **"Overhaul"** operations. These results can ONLY be utilized AFTER **'Containment'** has been confidently achieved and declared by Incident Command.

As a result, the **'Attack'** nozzle flow rate can be reduced from 60 GPM to only 20 GPM, in that given this produces 1/3rd of the original water-flow, the end result is 1/9th the Friction Loss (FL) component as previously calculated. Upon this significant reduction in Friction Loss (FL), Engine Pressure (EP) can be equally significantly reduced in which more laterals may be placed in service. To do so, will further assist the efficient full extinguish of every smoldering ember that always has the potential of creating a 'slop-over' (a term to mislead the media we have an 'Escape). It can drastically affect fireline safety if specific, proper measures are not exercised to prevent otherwise.

Please note, although the **"Overhaul"** Engine Pressures (EP) is significantly reduced, the color-coding to indicate just how close a driver/operator is to exhausting maximum Engine Pressure (EP) is NEVER eliminated. Regardless of whether in **'ATTACK'** mode or **"Overhaul"** mode, this will always keep the Driver/Operator aware of the risk that adequate **'ATTACK'** Nozzle Pressure (NP) may not be readily or FULLY available if **'ATTACK'** mode needs to be resumed.

Therefore, this is more evidence that every effort should be made to ensure all personnel remains in direct radio communication, per the Emergency Action (contingency) Plan, to include the potential temporary shut down of all NON-related/affected "Overhaul" nozzles. This will ensure the apparatus pump is still able to provide the minimum Engine Pressure (EP) to produce the minimum Nozzle Pressure (NP) required to mitigate any potential incident more efficiently and effectively.

Both the slide-rule and Phone Apps can independently select **"Overhaul"** mode to indicate these Engine Pressures (EP) accordingly. Corresponding colors always indicate in contrasting **BLACK, YELLOW,** and **RED** to effectively communicate and ***WARN*** the driver/operator these are NOT the Engine Pressure (EP) readings that will ever be adequate to produce the minimum Nozzle Pressure (NP) when engaging in and during severe fire behavior incidents and situations.

The following photographs are images of the Slide-Rule inserts and Phone App pages upon selecting “Overhaul” vs. “Attack” that clearly indicate “OVERHAUL” above each pressure result calculated. Again, these significantly reduced Engine Pressure (EP) results shall **never** be utilized or exercised at any time during the risk of any extreme fire behavior that may require immediate emergency mitigation procedures as deemed necessary. Please be extremely cautious to prevent confusing these results but primarily when engaged in aggressive fire attack when maximum pressure is required.

- **Standard “OVERHAUL”** Slide-Rule “overhaul” insert as:

	Length	100		200		300		400		500		600		700		800	
	Attack	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C
	Overhaul	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C
	Laterals																
	12																
	11																
	10																
	9																
	8																
Overhaul	7																
	6																
	5													Overhaul		Overhaul	
	4									Overhaul		Overhaul					
Standard	3					Overhaul		Overhaul						144	151	145	153
	2	Overhaul		Overhaul						126	130	127	132	139	145	140	146
	1					112	114	113	115	121	125	122	126	130	136	131	137
	0	101	102	102	103	108	110	109	111	115	118	116	119	122	126	123	127

	Length	900		1000		1100		1200		1300		1400		1500		1600	
	Attack	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C
	Overhaul	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C
	Laterals																
	12																
	11																
	10																
	9													Overhaul		Overhaul	
	8									Overhaul		Overhaul					
Overhaul	7					Overhaul		Overhaul						281	302	282	304
	6	Overhaul		Overhaul						235	253	236	254	271	292	272	294
	5					198	211	199	213	227	243	228	245	255	275	256	277
	4	168	178	169	179	191	203	191	205	213	228	214	230	229	254	230	255
Standard	3	161	171	162	172	178	190	179	192	195	210	196	211	212	229	213	231
	2	151	160	152	161	164	174	165	176	177	189	178	190	189	204	190	205
	1	140	147	141	148	149	157	150	159	158	168	159	170	168	179	169	181
	0	129	134	130	135	136	142	137	143	142	150	143	151	149	158	150	159

HEN-WAY' "OVERHAUL" Slide-Rule "overhaul" insert as:

	Length	100		200		300		400		500		600		700		800	
	Attack	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C
	Overhaul	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C
	Laterals																
	12												Add a 'HEN-WAY' before proceeding				
	11																
	10																
Overhaul	9																
	8																
	7																
	6																
HEN-WAY	5													Overhaul		Overhaul	
	4									Overhaul		Overhaul					
	3					Overhaul		Overhaul						133	131	142	145
	2	Overhaul		Overhaul						126	130	127	132	128	127	137	140
	1					112	114	113	115	121	125	122	126	123	120	132	134
	0	101	102	102	103	108	110	109	111	115	118	116	119	119	117	128	130

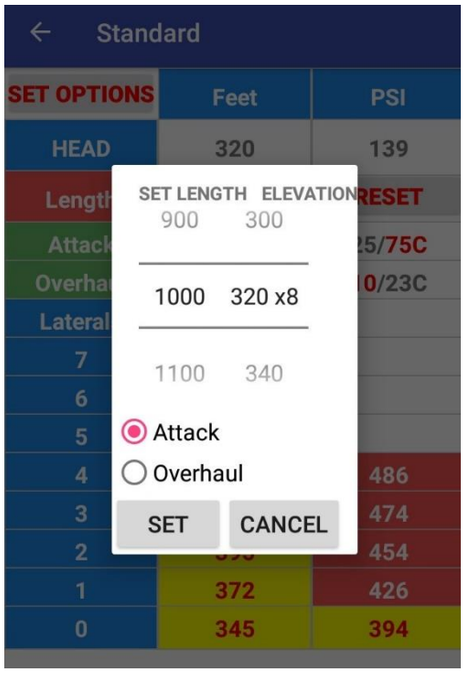
	Length	900		1000		1100		1200		1300		1400		1500		1600	
	Attack	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C	20C	25C
	Overhaul	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C	10/23C
	Laterals				Add a 'HEN-WAY' before proceeding								Add a 'HEN-WAY' before proceeding				
	12																
	11																
	10																
Overhaul	9													Overhaul		Overhaul	
	8									Overhaul		Overhaul					
	7					Overhaul		Overhaul						212	214	221	228
	6	Overhaul		Overhaul						186	189	195	202	205	208	214	221
HEN-WAY	5					169	1737	178	1751	181	183	190	197	197	198	206	212
	4	157	154	166	167	163	163	172	176	172	175	181	188	190	192	199	205
	3	153	148	162	162	156	155	165	169	167	168	176	182	182	182	191	196
	2	146	142	155	155	151	150	160	163	160	161	169	174	175	175	184	188
	1	143	137	152	151	145	143	154	157	155	154	164	168	167	166	176	180
	0	136	131	145	144	140	139	149	152	147	147	156	160	161	160	170	173

Please look below and compare the **"ATTACK"** mode at **423 PSI** (60C GPM Attack Nozzle upon a 1,000-foot hoselay with all four (4) 10 GPM laterals operating) **is UNSAFE to pump…** yet the **"OVERHAUL"** figure at **308 PSI** appears innocent. That's a **115 PSI reduction** in Engine Pressure (EP) now below the maximum 400 PSI threshold… but NOT during **"ATTACK"** or Emergency Operations! The **color-coding** remains to **WARN:**

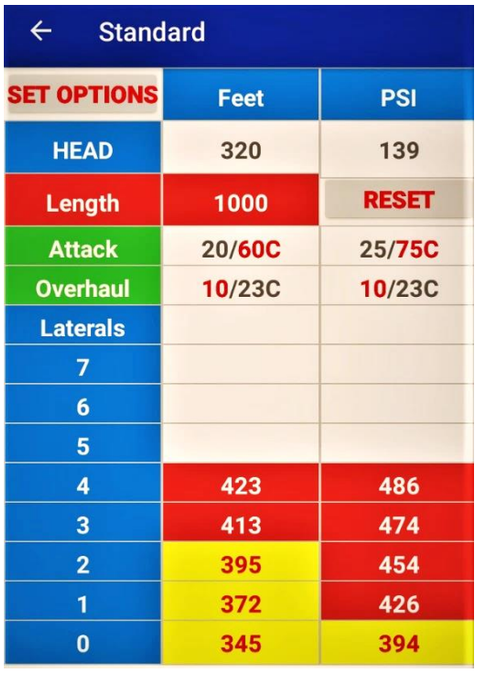
The procedure takes literally only seconds to complete a two a fast and simple (2) step process. It is the Driver/Operator's responsibility to ensure proper mode has been selected, and the length of the hoselay and estimated elevation is selected accurately.

Tap "SET OPTIONS"; select 'ATTACK'; select 'SET'; and read 'ATTACK' results.

'ATTACK' selector

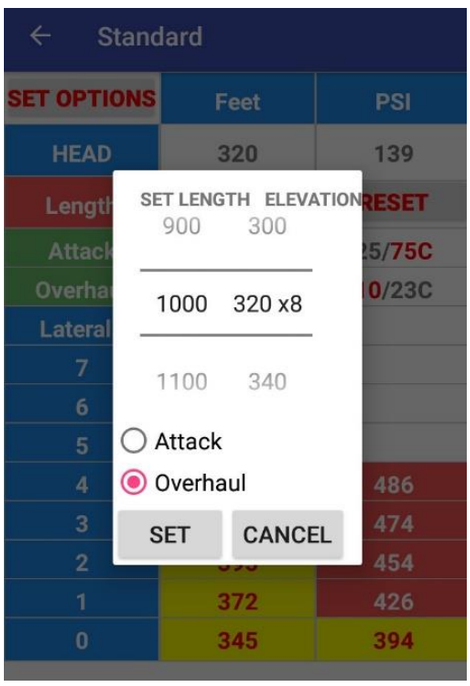


'ATTACK' mode

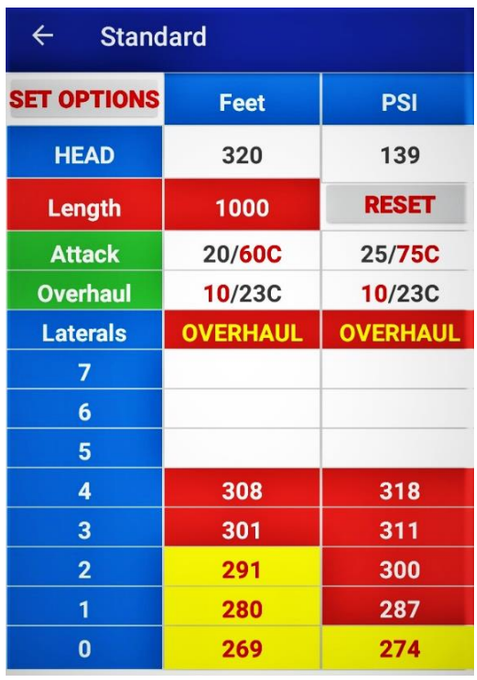


Tap "SET OPTIONS"; select 'Overhaul'; select 'SET'; and read "OVERHAUL" results.

"OVERHAUL" selector



"OVERHAUL" mode



Again, for the first time in Fire Service history, this resource dictates when and where to add a booster pump to re-establish and maintain an effective fire stream to ensure firefighter safety per **NFPA 1002 8.1 & 8.2.1(A), NFPA 1041 1.1 & 1.2.2, and OSHA 29 CFR 5(a)1 & 1910.156(c)1 & 2 accordingly.** **EVERY WILDLAND FIRE APPARATUS DRIVER/OPERATOR IS REQUIRED BY LAW TO UPHOLD THESE STANDARDS WITHOUT DEVIATION OR NEGLECT UPON OR UNDER ANY CIRCUMSTANCES EVER!**

<u>Chapter VI</u>: The Basics – Definition of Terms

As in all hydraulics calculations, wildland fire hydraulics is determined upon four (4) mathematical variables, that when totaled, accurately calculate proper Engine Pressure (EP). Proper (minimum) Engine Pressure (EP) is required to produce and maintain an effective fire stream at the rated water flow of the nozzle. These aspects are critical to ensure firefighter safety but especially upon the execution of any progressive wildland hoselay. The key is to keep up with the continuous progression of your crews but in ***<u>REAL-TIME</u>*** at literally every step of this critical fire suppression tactical operation.

To begin, we must always first consider the minimum required **<u>Nozzle Pressure (NP)</u>** of the "Attack-Nozzle" at the end connection of the hose before working our way back to the primary pump of the fire engine. Depending on the style of nozzle used (expressed in thread size and type), the internationally recognized NFPA standard requires a minimum of 50 PSI when utilizing a straight-bore "TIP" (T) style nozzle (listed by bore inside diameter and resulting GPM) and a minimum of 100 PSI for a "Combination" (C) style nozzle that produces both straight stream and fog patterns at variable flow rates expressed in Gallons Per Minute (GPM) accordingly.

The second consideration is **<u>Friction Loss (FL)</u>**. This is the most complex variable of the calculation process that is directly affected upon the amount of water flowing (GPM) through any individual section of any given pipe (or hose) at a specific diameter at the specified Nozzle Pressure (NP) at 50 PSI for a Straight-bore 'TIP' nozzle or 100 PSI for a Combination style nozzle presented as:

- **Friction Loss (FL) = (GPM/100)^2 * Coefficient of the hose * Length of hose/100'**
    - **Coefficient of 1 ½" Hose – Multiplier is <u>24</u>**
    - **Coefficient of 1" Hose – Multiplier is <u>150</u>**

In the simplest terms, given the viscosity of water at normal atmospheric temperatures and pressure, the flow rate (GPM) has a direct impact on this pressure loss. In regards to wildland firefighting, each section of an inch and a half (1 ½") "Attack-Line" or "Trunk-Line" in a hoselay is directly affected by the resulting flow (GPM) of the attack nozzle at the prescribed minimum required pressure ***<u>AND</u>*** the increased flow of water (GPM) in each affected section upon **<u>ADDING</u>** the flow of water (GPM) of each successive one-inch (1") by 100' lateral that is utilized for mop-up/overhaul purposes to

'secure' and 'anchor' the fire line of any given wildland fire today. A critical factor that increases the Friction Loss (FL) component in each individual affected and therefore unique section of hose exponentially that can ***NEVER*** be disqualified nor disregarded in this internationally accepted and instructed mathematical calculation process ***EVER.***

Then, once the Friction Loss (FL) of each individually affected section of the "Attack-Line/Trunk-Line" is accurately determined per their unique flow rates (GPM), this **subtotal** Friction Loss (FL) of all sections is then added together to the combined **subtotal** Friction Loss (FL) of each individual one-inch (1") by 100' lateral currently in operation. The sum of these two (2) figures, therefore, represents the ***GRAND TOTAL*** **Friction Loss (FL)** variable that is necessary to accurately calculate the total proper Engine Pressure (EP) for the entire progressive hoselay accordingly.

In the simplest terms, the inquiry, ***"Is not Friction Loss a direct mathematical function of Gallons Per Minute?"*** …is, therefore, a resounding and confirmed, ***"Yes!"***

The third mathematical variable is **Appliance Loss (A)**. This is based upon the number of inline one and a half-inch (1 ½") "Tees" necessary to connect and supply each one-inch (1") by 100' lateral utilized for mop-up/overhaul purposes. Again, in the same exact manner, a large boulder can slow the overall rate of water down a river or stream, each one-inch (1") water-restrictive stem/valve assembly that spans the full diameter within each of these one and a half (1 ½") "Tee" causes an Appliance Loss (A) pressure loss determined at an estimated 5 PSI each in the same manner.

The final and fourth (4^{th}) mathematical variable is the addition (+) or subtraction (-) of **HEAD pressure (H)**: This is the calculated increase of pressure [PLUS (+) upon the increase in elevation above the fire pump to the highest nozzle of the hoselay] or calculated decrease of pressure [MINUS (-) upon the decrease of elevation below the fire pump to the ***first operating nozzle of a hoselay ONLY!***] upon the weight of water at 0.434 PSI per foot (±) elevation change.

For structure firefighting purposes, this is a no brainer by comparison in that each floor above or below the ground floor of a pumper is typically 10 feet; in which this figure is subsequently rounded off to 5 PSI per floor. Upon counting from the second (2^{nd}) floor and going up from there, we add a **PLUS** (+) 5 PSI per floor. [(# Floor – one (1)) * 5 PSI] Conversely, when fighting basement fires, this amount is subtracted as a **MINUS** (-) 5 PSI per basement floor below the ground floor. [-1 * (# B. Floor) * 5 PSI] in

Both positive (+) and negative (-) HEAD are compensated at the pump upon the internationally accepted methodology to calculate Engine Pressure (EP) accordingly.

But when it comes to wildland fire fighting, this variable is not so easily calculated. The fire apparatus driver/operator must multiply **0.434 PSI/ft.** upon his/her ***'best estimation'*** of the change in elevation (The 'rise' over the given run of several hundred feet and more.) But this is often visually obstructed by vegetation and other land features that make this nearly impossible to determine at (+) or (-) 25% accuracy, to then be utilized to attempt to calculate proper Engine Pressure (EP) accurately.

But now, upon the ***REAL-TIME*** Geographic Positioning System (GPS) to verify the location of all personnel and resources (via radio communication due to the lack of an internet connection in remote areas) can be placed on a two (2) dimensional United States Geographic Survey (USGS) map. This is an extremely useful phone app that can be downloaded to any Android or iPhone **(www.GAIAGPS.com)** that not only identifies the (±) change in elevation in either 20 ft. or 40 ft. intervals, but In the same manner, a Land Surveyor measures all property lines from a known **BENCHMARK**, when standard GPS technology is utilized in conjunction with 'AVL' equipped fire apparatus, fire line safety is immensely enhanced! Personnel radio-notify their ***REAL-TIME*** situational awareness (best estimation of which contour line is near or above) from their 'AVL' fire vehicle **(BENCHMARK).** The benchmark that is monitored by dispatch and command staff that meets all safety criteria of **Section 5** of the ***"Wildfire Management Technology Advancement Act of 2018"*** as well. A first in Fire Service history!

Let's again review the internationally recognized Engine Pressure (EP) calculation formula as stated below upon the adherence to the correct methodology. The ***GRAND TOTAL*** Friction Loss (FL) component is always based upon the water flow (GPM) in each individually affected section of hose that changes upon the placement and operational use of every successive one-inch (1") by 100' lateral utilized for mop-up/overhaul mitigation purposes accordingly.

- **Engine Pressure (EP) = Nozzle Pressure (NP) + *GRAND TOTAL* Friction Loss (FL) + Appliance Loss (A) + [(+) or (-)] HEAD (H)**

It is a fire apparatus driver/operator's duty to accurately calculate and record each component upon as much confirmed intelligence that can be obtained in the field before adding all four (4) variables to calculate the actual Engine Pressure (EP)

accurately. But especially upon the need in ***REAL-TIME*** to establish and maintain the required minimum Nozzle Pressure (NP) at every step in a wildland fire hoselay that truly meets and exceeds every directive enforced by the mandate of the ***OSHA Section 5(a)(1) General Duty Clause*** umbrella to maximize firefighter safety under all conditions.

The purpose of the world's FIRST ever Wildland Fire Engine Pump Pressure/Hydraulics Calculator is to establish and maintain this requirement at every phase of advancing in hoselay. Both a mechanical Slide-Rule and the Android and iOS format phone apps accomplish this in mere seconds. A huge breakthrough in fire line safety that has never been experienced in Fire Service history before!

And now that Automatic Vehicle Location (AVL) equipment (upon redundant Cellular, VHF, and satellite GPS positioning communication methods/systems) is being installed (in over 1,200 CAL FIRE units alone) to improve the situational awareness of our fire apparatus/ resources, we can now determine by bearing and distance from these ***BENCHMARKS*** that are monitored 24/7/365, our firefighters can now be located to almost the nearest square inch by allowing full Computer-Aided Dispatch connectivity and continuous radio communicated position updates expressed in longitude and latitude coordinates of our frontline fire response, **the *"Holy Grail of Wildland Firefighting"* has finally been fulfilled!**

Chapter VII: The Breakdown

Nozzle Pressure (NP) 'Pressure Loss':

As there are many nozzle types and manufacturers worldwide, there are truly only two (2) versions that need to be considered: Straight bore "Tip" (T) and "Combination" style nozzles (C).

Straight bore "Tip" (T) nozzles are listed by thread size (i.e. 1" NPT or 1 ½" NST) and inside diameter and flow rates expressed in Gallons Per Minute (GPM) at 50 PSI. 50 PSI must be continuously maintained at the end connection of the hose to produce the desired flow rate (GPM) to fight a fire both SAFELY and efficiently to ensure firefighter safety and therefore meet OSHA's General Duty Clause listed above. A 1 ½" NST thread ½" "Tip" style nozzle will flow 53 GPM at 50 PSI nozzle pressure. This has been established as the minimum size tip/flow rate determined by many state government agency fire departments before ever fully engaging a wildland fire advancing at a ***"moderate rate of spread."***

and yet most federal agencies require 75 GPM flow rate Wildland "Combination" (C) style nozzles, on the other hand, require 100 PSI to establish and maintain the minimum flow rate (GPM) at the end connection of the hose to fight a fire both SAFELY and efficiently. All are again listed by thread size and type (i.e., 1" NPT or 1 ½" NST) at their minimum and maximum GPM flow rates (i.e. "10/23"; "20/60"; "25/75"; etc.) accordingly. These nozzles can transition from the lower flow rate (GPM) to the next and back and produce a fire stream that can be either in a straight-stream fashion (similar to a straight bore "Tip") or variable 'fog' pattern wide-angle fire stream.

In all cases, a quarter turn 'ball-valve' assembly at the hose/nozzle connection is the preferred method to initiate, adjust and then cease the rate of flow of both the straight-bore "Tip" and "Combination" style nozzles alike.

Friction Loss (FL) 'Pressure Loss':

To begin to fully understand how we determine this portion of the calculation process, we need to respect the internationally recognized calculation formula methodology. This formula has been utilized for more than a century to determine the minimum parameters for all our water fire protection systems (hydrants, sprinklers, etc.). The Great Chicago Fire and the San Francisco Earthquake of 1906 made it apparent that minimum flow rates and pressure standards were needed to prevent the 'conflagrations' experienced.

The internationally recognized and respected basic hydraulics Friction Loss (FL) formula:

- **Friction Loss = (<u>GPM</u>/100)^2 X (<u>Coefficient</u> of the Hose) X (<u>Length</u> at a specific flow rate)/100')**
    1. In that, the **<u>Coefficient</u>** for **<u>1"</u>** diameter fire hose utilizes the multiplier of **<u>150</u>**…
    2. In that, the **<u>Coefficient</u>** for **<u>1 ½"</u>** diameter fire hose utilizes the multiplier of **<u>24</u>**…

But before we begin to discuss the proper application of the formula necessary to complete this portion of the calculation process, we must first understand the physical dynamics involved to arrive at such a result.

First, let's consider any typical river or creek coursing down-stream. The water flow is fast and efficient at the top and in the middle of the primary flow area, yet much slower on the edges and therefore at the bottom as well. Friction loss (FL) is best understood as this component, given the measured viscosity of water under normal temperatures and atmospheric pressures, that when the water makes contact with the edges (in this case the bottom and sides) of its designated channel, 'eddies' are created as it moves downstream. The overall rate of flow is therefore reduced by this resulting friction.

In the exact same way, the inside diameter of a pipe, given its cylindrical shape, determines the surface area to volume ratio. Again given the measured viscosity of water, turbulence or 'eddies' are created at a predictable size and rate. The more water is forced through a given pipe, the larger these 'eddies' become. As these 'eddies' increase in size, the overall 'usable' inside diameter of the pipe is reduced. As the 'usable' diameter is exponentially reduced, its volume or capacity to flow water is then equally exponentially reduced regardless of a manufacturer's efforts to ensure the inside surface of the hose is created as smooth as possible.

Practically speaking, ***"What does all this mean?"***

- This is why when we double (2X) the water flow (GPM) in a given pipe or hose, the Friction Loss (FL) component increases by a multiplier of two (2) squared… or four (4) times the amount.
- In that three (3) times the flow of water (GPM) in the same pipe is three (3) squared… or nine (9) times the amount of Friction Loss (FL).
- And yet, if we attempt to maintain the same flow rate (GPM) but in a pipe one-half (½) the original diameter of the first, the resulting Friction Loss (FL) component increases by a multiplier of 32 times!

If we look at any internationally recognized Friction Loss (FL) table, per the supporting evidential exhibits attached, we find this consistently illustrated as true. This is why we experience such an incredible benefit by establishing a second dual/parallel 'Supply-Line' when attempting to flow large quantities of water over great distances from a hydrant to the fire. The Friction Loss (FL) component is calculated by squaring the fraction equal to "½" the GPM in each. So "½" the flow times (X) "½" the flow then results in "¼" the Friction Loss (FL) as the coefficient of the hose always remains constant. This results in a 75% reduction in Friction Loss (FL) when calculating the **TOTAL** necessary water pressure and resulting flow to complete the evolution, simply by adding just one (1) more parallel line.

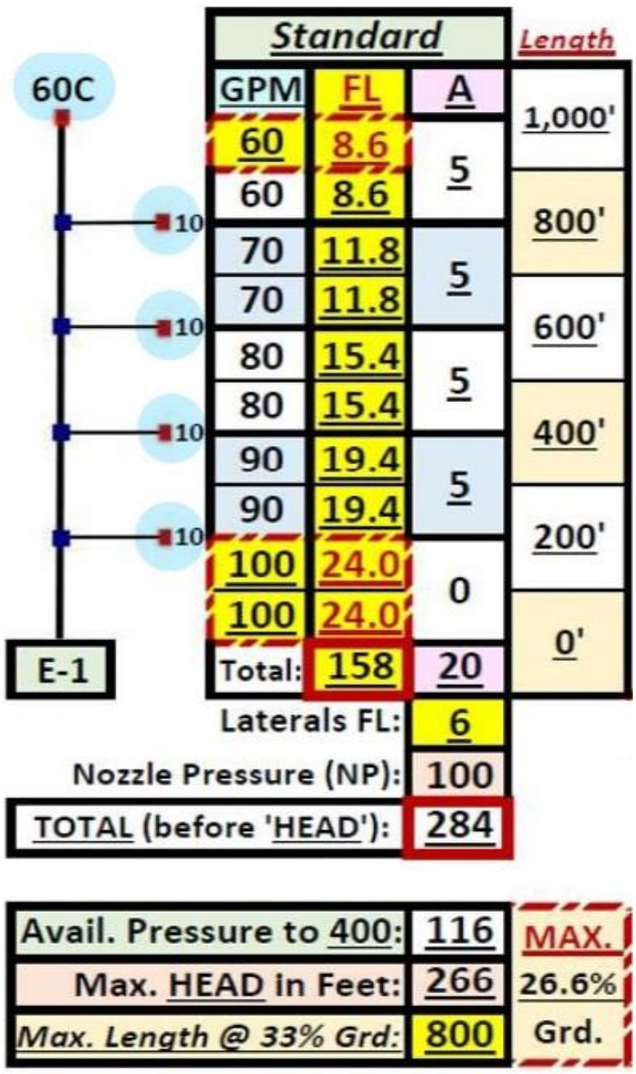
Another example, to establish exposure protection from a more advantageous strategic location that may be over a great distance may call for laying yet a third (3rd) parallel 2 ½" Attack-line. In pressurizing a high flow (GPM) portable monitor nozzle (appliance), the Friction Loss (FL) component is reduced in that the equally divided "1/3" the flow (GPM) times (X) "1/3" the flow (GPM) results in "1/9" the Friction Loss (FL). This now results in an 89% reduction in the Friction Loss (FL) component when calculating the **TOTAL** Engine Pressure (EP) required with incidents of this magnitude.

The internationally recognized calculation methodology above has been respected and adhered to by all affected local, state/province, and federal entities requiring its proper application to establish adequate water fire protection worldwide for well over a century and a half.

This is where it gets a little dicey for the wildland fire apparatus driver/operator. He/she must calculate the rate of water (GPM) through each individually affected section of 1 ½" 'Attack-line'/'Trunk-line' utilized in a progressive hoselay. The rate of flow (GPM) in each individual section is directly affected by the actual flow rate (GPM) of the attack nozzle **PLUS** the flow rate (GPM) of all successive operating individual one-inch (1") by 100' laterals at specific intervals further up the 'Attack-line'/'Trunk-line'.

Chapter VIII: The Calculations

As previously outlined, all examples are a one and half inch (1 ½") by 1,000' 'Attack-Line'/'Trunk-Line' hoselay, with a 1 ½" 20/60 'Attack' combination nozzle flowing ***60 GPM*** at **100 PSI** **Nozzle Pressure (NP).** There is also a total of four (4) 1" by 100' laterals every 200', each equipped with a 10/23 GPM combination nozzle flowing ***10 GPM*** for mop-up/overhaul purposes. The following breakdown is evidenced as follows:



1. **Between 800' and 1,000'** the 1 ½" 20/60 'Attack' combination nozzle causes **60 GPM** to flow through this 200' section at ***8.6 PSI*** Friction Loss per 100'… or ***17.2 PSI TOTAL*** Friction Loss (FL) in this specific 200' section of 1 ½" **only**.
2. **Between 600' and 800,'** the 1 ½" 20/60 'Attack' combination nozzle causes **60 GPM** to flow through this 200' section is then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 800' in that **70 GPM** causes ***11.8 PSI*** Friction Loss per 100'… or ***23.6 PSI TOTAL*** Friction Loss (FL) in this specific section **only.**
3. **Between 400' and 600'** the 1 ½" 20/60 'Attack' combination nozzle causes **60 GPM** to flow through this 200' section is then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 800' and then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 600' in that **80 GPM** causes **15.4 PSI** Friction Loss per 100'… or ***30.8 PSI TOTAL*** Friction Loss (FL) in this specific section **only.**
4. **Between 200' and 400'** the 1 ½" 20/60 'Attack' combination nozzle causes **60 GPM** to flow through this 200' section is then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 800' and then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 600' and then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 400' in that **90 GPM** causes **19.4 PSI** Friction Loss per 100'… or ***38.8 PSI TOTAL*** Friction Loss (FL) in this specific section **only.**

5. **Between the Fire Engine and 200,'** the 1 ½" 20/60 'Attack' combination nozzle causes **60 GPM** to flow through this 200' section is then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 800'; and then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 600'; and then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 400'; and then **ADDED** to the additional **10 GPM** for the 1" by 100' lateral at 200'. **100 GPM** causes **24.0 PSI** Friction Loss per 100'… or ***48.0 PSI TOTAL*** Friction Loss (FL) in this specific section **only.**

The **subtotal Friction Loss (FL)** of each of the five (5) individually calculated sections of the 1 ½" 'Attack-Line'/'Trunk-Line' is determined by **ADDING each result of each individually affected section as** ***17.2 PSI*** + ***23.6 PSI*** + ***30.80 PSI*** + ***38.8 PSI*** + ***48.0 PSI*** to thus equal (=) **158.0 PSI**

It is then necessary to calculate the Friction Loss (FL) component for the water pressure loss of each 1" by 100' lateral per the internationally recognized formula and methodology above. Each 100' length with a 10/23 GPM combination nozzle flowing **10 GPM** has a Friction Loss (FL) of ***1.5 PSI each***. Since we have one at 200', a second at 400', a third at 600', and finally a fourth at 800':

The **subtotal Friction Loss (FL)** for all **four (4)** 1" by 100' laterals at **1.5 PSI** each is (=) **6.0 PSI.**

The **GRAND TOTAL Friction Loss (FL)** component required to accurately calculate proper Engine Pressure (EP) is proven by **adding the subtotal Friction Loss each of the five (5) individually affected sections of the 1 ½" 'Attack-Line'. We ADD this 158.0 PSI to the subtotal Friction Loss (FL) of all four (4) 1" laterals at 6.0 PSI which equals (=) 164.0 PSI.**

Appliance Loss (A) Pressure Loss:

In the same manner that a large boulder restricts the flow of water in a river or creek, any parasitic obstruction within any plumbing and/or pipe or hose must also be considered to calculate for the Appliance Loss (A)

Given there are four (4) 1 ½" X 1" 'Tees' (each with interior 'water-restrictive' valve stem assemblies) in the 1,000' hoselay above, we shall calculate each at **5 PSI** in that **four (4)** times (X) **5 PSI** equals (=) **20 PSI**

The ***TOTAL* PRESSURE LOSS** is the addition of the **Nozzle Pressure (NP) [100 PSI]**, ***PLUS*** (+) the **'*GRAND TOTAL'* Friction Loss (FL)** of the 1 ½" Attack-line/Trunk-line **[158 PSI]** added to the **'*subtotal' Friction Loss (FL)*** of all four (4) 1" by 100' laterals **[6 PSI]** equals (=) **164 PSI *PLUS*** (+) **Appliance Loss (A)** at **[20 PSI]** which equals (=) **284 PSI**

This is the initial figure that the Slide-Rule and both phone apps provide. You will recall that this leaves only **116 PSI** of the 400 PSI maximum Engine Pressure (EP) that our fire apparatus can produce to SAFELY allow for the final component to be added - **HEAD (H) pressure** . Dividing **116 PSI** by **0.434 PSI/ft** equals **266 feet. Given this is over a 1,000' run, this is a 26.6% Grade.** Any steeper than this, the maximum amount of vertical elevation [(+) HEAD] will compromise the **OSHA General Duty Clause 5(a)(1)** requirement to establish and maintain an effective fire stream for firefighter safety.

The calculation for the maximum length at a 29% Grade, in a 1,000' run is 290'. 290' times (X) 0.434 PSI/ft equals 126 PSI. 400 PSI minus (-) 126 PSI equals **274 PSI** available to pump water. The calculations for 60 GPM 'Attack' and all four (4) laterals operating at 10 GPM requires 276 PSI at 900'. Given it is only 2 PSI more than the maximum at 274 PSI calculated, it would likely be safe enough to pump a 900' hoselay at a 29% grade. But nothing longer nor nothing steeper is possible without violating 29 CFR 1910.156 training and performance standards upon NFPA's 1002 to produce an effective fire stream at the rated flow/capacity of the nozzle… as every instructed is mandated to teach under NFPA 1041 Instructor Qualification Standards.

At this point, a hoselay 'Attack-line'/'Trunk-line' still cannot be SAFELY extended even one (1) more 100' length to 1,100' of 1 ½" 'Attack-Line/'Trunk-Line' even with only two (2) 1" laterals operating at 283 PSI. The HEAD pressure at this continuous rise-over-run for the next 100' distance will increase from 290' to 319 feet. When we multiply 319 times 0.434 PSI/ft, it equals 138 PSI in Total HEAD pressure loss. If we only have 117 PSI available before exhausting the maximum Engine Pressure (EP) at 400 PSI, we are therefore in direct violation of 29 CFR 1910.156 upon NFPA 1002 and 1041 Instructor Qualification Standards yet again.

The final concern, when establishing minimum Nozzle Pressure (NP) at the end of a 1,000' hoselay with up to four (4) laterals operating simultaneously, is when the resulting Friction Loss (FL) component is reduced as mop-up/overhaul operations are being completed and there are subsequently only three (3) 1" by 100' laterals operating yet four (4) water-restrictive "Tees" that remain in place. The end result is only **90 GPM**

flows through the first 400' of 1 ½" 'Attack-Line/'Trunk-Line' between the Fire Engine to next (2nd) operating lateral at 400' up the hoselay. This lowers the calculated **Grand Total Friction Loss (FL)** variable a full **10 PSI** because the Nozzle Pressure (NP), Friction Loss (FL) of both the 1 ½" and the 1" hose, and the appliance loss of four (4) "Tees" at 5 PSI each remains constant to arrive at the subtotal of **274 PSI**.

When only two (2) 1" by 100' laterals of the original four (4) total are operating, the end result is only **80 GPM** will be flowing through the first 600' of the 1 ½" 'Attack-Line/'Trunk-Line' between the Fire Engine to the next (3rd) 1" by 100' lateral operating. This again lowers the overall **Grand Total Friction Loss (FL)** variable a full **28 PSI** to **256 PSI.** (Nozzle Pressure (NP), Friction Loss (FL) of this reduced water-flow-rate within the 1 ½" and the 1" hose, and the appliance loss of four (4) "Tees" at 5 PSI each.)

Again when only one (1) 1" by 100' laterals of the original four (4) total are operating, the end result is only **70 GPM** flowing through the first 800' of the 1 ½" 'Attack-Line/'Trunk-Line.' This again lowers the overall **Grand Total Friction Loss (FL)** variable a full **51 PSI** to **233 PSI**. (Nozzle Pressure (NP), Friction Loss (FL) of this reduced water- flow-rate within the 1 ½" and the 1" hose, and the appliance loss of four (4) "Tees" at 5 PSI each)

If no 1" by 100' laterals of the original four (4) total are operating, the end result is only **60 GPM** flowing through the first 1,000'. Again lowering the overall **Grand Total Friction Loss (FL)** variable a full **78 PSI** to **206 PSI.**

When considering **OVERHAUL** operations, when the 20/60 GPM nozzle is reduced to only 20 GPM and all other nozzles remain at 10 GPM, these figures exponentially change at a similar rate. But again, these Engine Pressure results shall ***ONLY*** be utilized during operations when you are confident an aggressive attack is significantly reduced. The color-coding of each result shall remain unchanged as a ***WARNING*** in the event of the need to escalate to 'ATTACK' mode. This is why it is critical to maintain radio contact with all Mop-Up/Overhaul nozzle operators to temporarily cease (shut-down) all 'unaffected' overhaul lines/laterals in place. This will divert ALL water (and subsequent increased nozzle pressure) to the area of the emergency but especially when the minimum required Engine Pressure (EP) to produce the minimum Nozzle Pressure, ensuring firefighter safety per 29 CFR 1910.156 of NFPA 1041, may be marginal at best.

(±) HEAD (H) Pressure Loss and/or Gain:

The subtotal of the Nozzle Pressure (NP), Friction Loss (FL) and Appliance (A) loss on the Slide-Rule and both phone apps, when subtracted from 400 PSI, instantly determines if the driver/operator can execute this possibility ***BEFORE*** it is attempted, to maintain firefighter safety.

Any USGS Topo Map immediately provides our GPS location on a grid map that illustrates isobars that indicate either 20’ elevation gradients (at lower elevation areas) or 40’ elevation gradients (at higher elevation areas). This allows us to count the accurate positive (+) or negative (-) changes in elevation between a driver/operator’s (fire apparatus) location and an established waypoint(s).

Friction Loss Calculator - 100 Feet of 1 ½" Hose

GPM	FL	GPM	FL	GPM	FL	GPM	FL	GPM	FL	GPM	FL	GPM	FL	GPM	FL
1	0.0	51	6.2	101	24.5	151	54.7	201	97.0	251	151.2	301	217.4	351	295.7
2	0.0	52	6.5	102	25.0	152	55.4	202	97.9	252	152.4	302	218.9	352	297.4
3	0.0	53	6.7	103	25.5	153	56.2	203	98.9	253	153.6	303	220.3	353	299.1
4	0.0	54	7.0	104	26.0	154	56.9	204	99.9	254	154.8	304	221.8	354	300.8
5	0.1	55	7.3	105	26.5	155	57.7	205	100.9	255	156.1	305	223.3	355	302.5
6	0.1	56	7.5	106	27.0	156	58.4	206	101.8	256	157.3	306	224.7	356	304.2
7	0.1	57	7.8	107	27.5	157	59.2	207	102.8	257	158.5	307	226.2	357	305.9
8	0.2	58	8.1	108	28.0	158	59.9	208	103.8	258	159.8	308	227.7	358	307.6
9	0.2	59	8.4	109	28.5	159	60.7	209	104.8	259	161.0	309	229.2	359	309.3
10	0.2	60	8.6	110	29.0	160	61.4	210	105.8	260	162.2	310	230.6	360	311.0
11	0.3	61	8.9	111	29.6	161	62.2	211	106.9	261	163.5	311	232.1	361	312.8
12	0.3	62	9.2	112	30.1	162	63.0	212	107.9	262	164.7	312	233.6	362	314.5
13	0.4	63	9.5	113	30.6	163	63.8	213	108.9	263	166.0	313	235.1	363	316.2
14	0.5	64	9.8	114	31.2	164	64.6	214	109.9	264	167.3	314	236.6	364	318.0
15	0.5	65	10.1	115	31.7	165	65.3	215	110.9	265	168.5	315	238.1	365	319.7
16	0.6	66	10.5	116	32.3	166	66.1	216	112.0	266	169.8	316	239.7	366	321.5
17	0.7	67	10.8	117	32.9	167	66.9	217	113.0	267	171.1	317	241.2	367	323.3
18	0.8	68	11.1	118	33.4	168	67.7	218	114.1	268	172.4	318	242.7	368	325.0
19	0.9	69	11.4	119	34.0	169	68.5	219	115.1	269	173.7	319	244.2	369	326.8
20	1.0	70	11.8	120	34.6	170	69.4	220	116.2	270	175.0	320	245.8	370	328.6
21	1.1	71	12.1	121	35.1	171	70.2	221	117.2	271	176.3	321	247.3	371	330.3
22	1.2	72	12.4	122	35.7	172	71.0	222	118.3	272	177.6	322	248.8	372	332.1
23	1.3	73	12.8	123	36.3	173	71.8	223	119.3	273	178.9	323	250.4	373	333.9
24	1.4	74	13.1	124	36.9	174	72.7	224	120.4	274	180.2	324	251.9	374	335.7
25	1.5	75	13.5	125	37.5	175	73.5	225	121.5	275	181.5	325	253.5	375	337.5
26	1.6	76	13.9	126	38.1	176	74.3	226	122.6	276	182.8	326	255.1	376	339.3
27	1.7	77	14.2	127	38.7	177	75.2	227	123.7	277	184.1	327	256.6	377	341.1
28	1.9	78	14.6	128	39.3	178	76.0	228	124.8	278	185.5	328	258.2	378	342.9
29	2.0	79	15.0	129	39.9	179	76.9	229	125.9	279	186.8	329	259.8	379	344.7
30	2.2	80	15.4	130	40.6	180	77.8	230	127.0	280	188.2	330	261.4	380	346.6
31	2.3	81	15.7	131	41.2	181	78.6	231	128.1	281	189.5	331	262.9	381	348.4
32	2.5	82	16.1	132	41.8	182	79.5	232	129.2	282	190.9	332	264.5	382	350.2
33	2.6	83	16.5	133	42.5	183	80.4	233	130.3	283	192.2	333	266.1	383	352.1
34	2.8	84	16.9	134	43.1	184	81.3	234	131.4	284	193.6	334	267.7	384	353.9
35	2.9	85	17.3	135	43.7	185	82.1	235	132.5	285	194.9	335	269.3	385	355.7
36	3.1	86	17.8	136	44.4	186	83.0	236	133.7	286	196.3	336	271.0	386	357.6
37	3.3	87	18.2	137	45.0	187	83.9	237	134.8	287	197.7	337	272.6	387	359.4
38	3.5	88	18.6	138	45.7	188	84.8	238	135.9	288	199.1	338	274.2	388	361.3
39	3.7	89	19.0	139	46.4	189	85.7	239	137.1	289	200.5	339	275.8	389	363.2
40	3.8	90	19.4	140	47.0	190	86.6	240	138.2	290	201.8	340	277.4	390	365.0
41	4.0	91	19.9	141	47.7	191	87.6	241	139.4	291	203.2	341	279.1	391	366.9
42	4.2	92	20.3	142	48.4	192	88.5	242	140.6	292	204.6	342	280.7	392	368.8
43	4.4	93	20.8	143	49.1	193	89.4	243	141.7	293	206.0	343	282.4	393	370.7
44	4.6	94	21.2	144	49.8	194	90.3	244	142.9	294	207.4	344	284.0	394	372.6
45	4.9	95	21.7	145	50.5	195	91.3	245	144.1	295	208.9	345	285.7	395	374.5
46	5.1	96	22.1	146	51.2	196	92.2	246	145.2	296	210.3	346	287.3	396	376.4
47	5.3	97	22.6	147	51.9	197	93.1	247	146.4	297	211.7	347	289.0	397	378.3
48	5.5	98	23.0	148	52.6	198	94.1	248	147.6	298	213.1	348	290.6	398	380.2
49	5.8	99	23.5	149	53.3	199	95.0	249	148.8	299	214.6	349	292.3	399	382.1
50	6.0	100	24.0	150	54.0	200	96.0	250	150.0	300	216.0	350	294.0	400	384.0

Friction Loss Calculator - 100 Feet of 1" Hose

GPM	FL	GPM	FL	GPM	FL	GPM	FL	GPM	FL	GPM	FL	GPM	FL	GPM	FL
1	0.0	51	39.0	101	153.0	151	342.0	201	606.0	251	945.0	301	1359.0	351	1848.0
2	0.1	52	40.6	102	156.1	152	346.6	202	612.1	252	952.6	302	1368.1	352	1858.6
3	0.1	53	42.1	103	159.1	153	351.1	203	618.1	253	960.1	303	1377.1	353	1869.1
4	0.2	54	43.7	104	162.2	154	355.7	204	624.2	254	967.7	304	1386.2	354	1879.7
5	0.4	55	45.4	105	165.4	155	360.4	205	630.4	255	975.4	305	1395.4	355	1890.4
6	0.5	56	47.0	106	168.5	156	365.0	206	636.5	256	983.0	306	1404.5	356	1901.0
7	0.7	57	48.7	107	171.7	157	369.7	207	642.7	257	990.7	307	1413.7	357	1911.7
8	1.0	58	50.5	108	175.0	158	374.5	208	649.0	258	998.5	308	1423.0	358	1922.5
9	1.2	59	52.2	109	178.2	159	379.2	209	655.2	259	1006.2	309	1432.2	359	1933.2
10	1.5	60	54.0	110	181.5	160	384.0	210	661.5	260	1014.0	310	1441.5	360	1944.0
11	1.8	61	55.8	111	184.8	161	388.8	211	667.8	261	1021.8	311	1450.8	361	1954.8
12	2.2	62	57.7	112	188.2	162	393.7	212	674.2	262	1029.7	312	1460.2	362	1965.7
13	2.5	63	59.5	113	191.5	163	398.5	213	680.5	263	1037.5	313	1469.5	363	1976.5
14	2.9	64	61.4	114	194.9	164	403.4	214	686.9	264	1045.4	314	1478.9	364	1987.4
15	3.4	65	63.4	115	198.4	165	408.4	215	693.4	265	1053.4	315	1488.4	365	1998.4
16	3.8	66	65.3	116	201.8	166	413.3	216	699.8	266	1061.3	316	1497.8	366	2009.3
17	4.3	67	67.3	117	205.3	167	418.3	217	706.3	267	1069.3	317	1507.3	367	2020.3
18	4.9	68	69.4	118	208.9	168	423.4	218	712.9	268	1077.4	318	1516.9	368	2031.4
19	5.4	69	71.4	119	212.4	169	428.4	219	719.4	269	1085.4	319	1526.4	369	2042.4
20	6.0	70	73.5	120	216.0	170	433.5	220	726.0	270	1093.5	320	1536.0	370	2053.5
21	6.6	71	75.6	121	219.6	171	438.6	221	732.6	271	1101.6	321	1545.6	371	2064.6
22	7.3	72	77.8	122	223.3	172	443.8	222	739.3	272	1109.8	322	1555.3	372	2075.8
23	7.9	73	79.9	123	226.9	173	448.9	223	745.9	273	1117.9	323	1564.9	373	2086.9
24	8.6	74	82.1	124	230.6	174	454.1	224	752.6	274	1126.1	324	1574.6	374	2098.1
25	9.4	75	84.4	125	234.4	175	459.4	225	759.4	275	1134.4	325	1584.4	375	2109.4
26	10.1	76	86.6	126	238.1	176	464.6	226	766.1	276	1142.6	326	1594.1	376	2120.6
27	10.9	77	88.9	127	241.9	177	469.9	227	772.9	277	1150.9	327	1603.9	377	2131.9
28	11.8	78	91.3	128	245.8	178	475.3	228	779.8	278	1159.3	328	1613.8	378	2143.3
29	12.6	79	93.6	129	249.6	179	480.6	229	786.6	279	1167.6	329	1623.6	379	2154.6
30	13.5	80	96.0	130	253.5	180	486.0	230	793.5	280	1176.0	330	1633.5	380	2166.0
31	14.4	81	98.4	131	257.4	181	491.4	231	800.4	281	1184.4	331	1643.4	381	2177.4
32	15.4	82	100.9	132	261.4	182	496.9	232	807.4	282	1192.9	332	1653.4	382	2188.9
33	16.3	83	103.3	133	265.3	183	502.3	233	814.3	283	1201.3	333	1663.3	383	2200.3
34	17.3	84	105.8	134	269.3	184	507.8	234	821.3	284	1209.8	334	1673.3	384	2211.8
35	18.4	85	108.4	135	273.4	185	513.4	235	828.4	285	1218.4	335	1683.4	385	2223.4
36	19.4	86	110.9	136	277.4	186	518.9	236	835.4	286	1226.9	336	1693.4	386	2234.9
37	20.5	87	113.5	137	281.5	187	524.5	237	842.5	287	1235.5	337	1703.5	387	2246.5
38	21.7	88	116.2	138	285.7	188	530.2	238	849.7	288	1244.2	338	1713.7	388	2258.2
39	22.8	89	118.8	139	289.8	189	535.8	239	856.8	289	1252.8	339	1723.8	389	2269.8
40	24.0	90	121.5	140	294.0	190	541.5	240	864.0	290	1261.5	340	1734.0	390	2281.5
41	25.2	91	124.2	141	298.2	191	547.2	241	871.2	291	1270.2	341	1744.2	391	2293.2
42	26.5	92	127.0	142	302.5	192	553.0	242	878.5	292	1279.0	342	1754.5	392	2305.0
43	27.7	93	129.7	143	306.7	193	558.7	243	885.7	293	1287.7	343	1764.7	393	2316.7
44	29.0	94	132.5	144	311.0	194	564.5	244	893.0	294	1296.5	344	1775.0	394	2328.5
45	30.4	95	135.4	145	315.4	195	570.4	245	900.4	295	1305.4	345	1785.4	395	2340.4
46	31.7	96	138.2	146	319.7	196	576.2	246	907.7	296	1314.2	346	1795.7	396	2352.2
47	33.1	97	141.1	147	324.1	197	582.1	247	915.1	297	1323.1	347	1806.1	397	2364.1
48	34.6	98	144.1	148	328.6	198	588.1	248	922.6	298	1332.1	348	1816.6	398	2376.1
49	36.0	99	147.0	149	333.0	199	594.0	249	930.0	299	1341.0	349	1827.0	399	2388.0
50	37.5	100	150.0	150	337.5	200	600.0	250	937.5	300	1350.0	350	1837.5	400	2400.0

National Wildfire Coordinating Group

NWCG | Executive Board | Committees | Publications | Positions | Training | Tool Box | Search

3.3 Friction Loss in Fire Hose

Friction loss is the resulting resistance as water (fluid) moves along the inside wall of either a hose, pipe, or hose fittings.

Points to remember about friction loss:

1. Friction loss increases as flow (gpm) increases.
2. Total friction loss varies with length -- the greater the length, the higher the friction loss.
3. Friction losses on reeled hose average about 21 percent more than for straight hose lays.
4. Friction loss is nearly independent of pressure.
5. Friction loss varies with type, lining, weave, quality, and age of the hose.
6. Friction loss increases 4 times for each doubling of water flow. Reducing the diameter of a hose by 1/2 will increase the friction loss by a factor of 32 for the same flow.

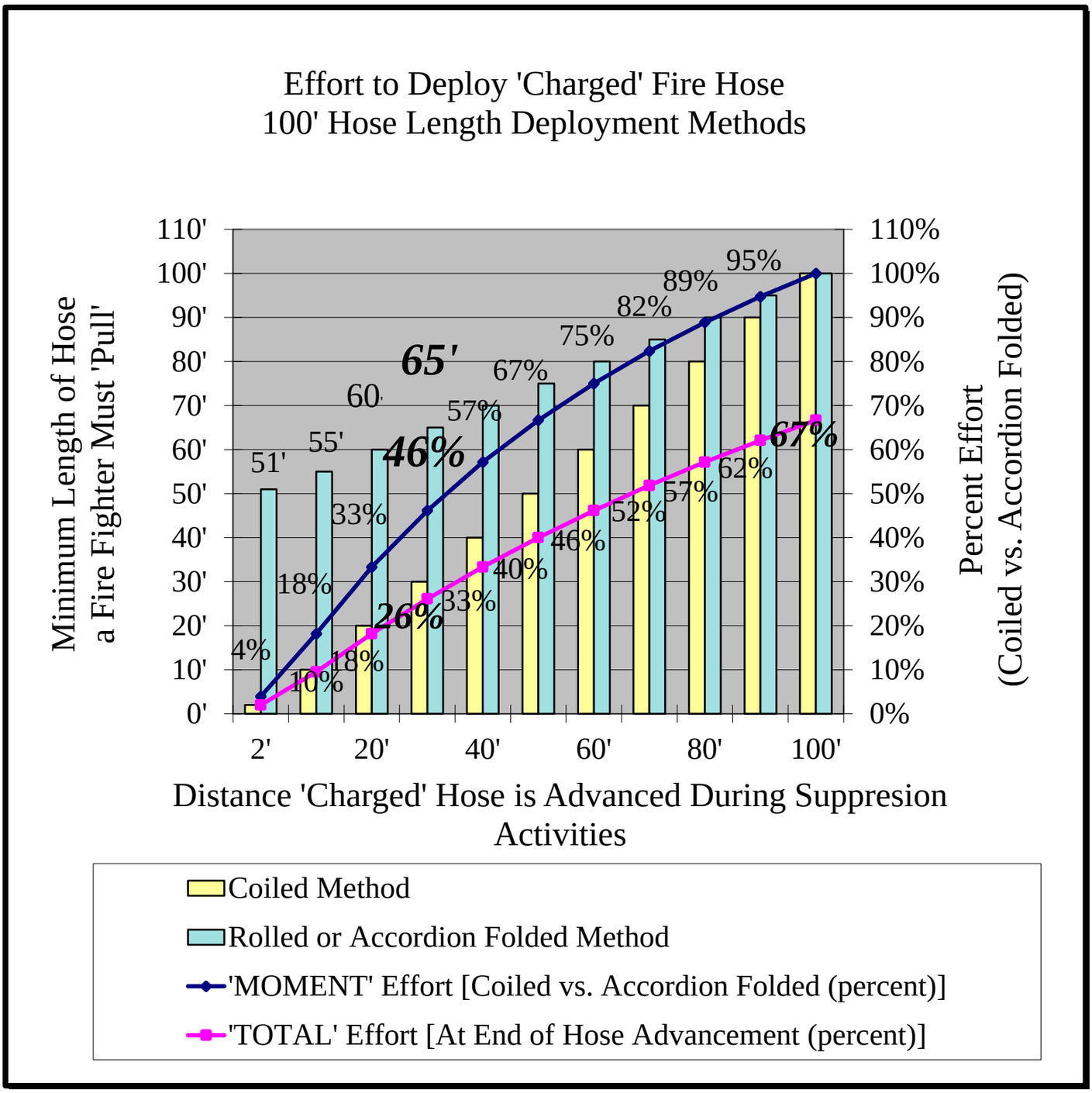
To account for friction loss, the pressure at which the pump is working must be increased. The pump pressure must also be or decreased to compensate for the head loss or gain, to produce the desired nozzle pressure.

The NWCG is the authority to all wildland fire training standards set nationwide as a template for the rest of the world to follow. Please take a moment to visit their website at https://www.nwcg.gov to obtain the information you need to push your career forward in the direction only you know that will best serve you… so you can better serve others.

BE SAFE… BE FIRELINE SAFE!

Effort to Deploy Fire Hose

'Bundle' (Coiled) vs. Folded/'Double-Donut' Rolled
'Moment' and 'Total' Energy Expended/Required



.

The purpose of this graph is to mathematically prove the advantages of utilizing the Laws of Physics that apply to a basic garden hose found 'coiled' at its water supply (faucet) also applies to ALL fire hose. In that 'Moment' energy and 'Total' energy are fully illustrated and compare the deployment of two (2) basic methods.

The first basic configuration is the traditional and most popular 'minuteman' or 'triple-fold' flat load or 'double-donut' roll (100') that requires literally every

fold to fit within a specific compartment or cabinet on fire apparatus. This creates a pre-engineered water restrictive kink that MUST FIRST always be painstakingly unfolded before the first drop of water is adequately pressurized to produce the necessary Nozzle Pressure (NP) for firefighter SAFETY. The second (and least popular?) is the 'Coiled' method (i.e. Cleveland, Gnass, etc.) that can be fully charged literally in mere seconds… within feet of the pressurized source… and especially in confined spaces where ZERO manipulation of the hose is required to secure FULL Nozzle Pressure (NP) at every stage of deployment…within feet of a fire apparatus… up to the full length of the hose. [**http://HoseRoller.net**]

Please carefully identify each component of this graph. The ***BLUE BAR*** graph illustrates the typical 50' 'tail' of hose that is dragged behind a firefighter when advancing/pulling a 150' 'pre-connect' or 'Live-Line' of folded hose. It also represents the minimum of 50' behind a 100' 'Double-Donut' roll of hose that is (stupidly?) unrolled, in reverse, back down the steep rugged terrain of the very hill just traversed.

The ***YELLOW BAR*** illustrates the 'tail' of hose that is dragged behind a firefighter when advancing/pulling 100' of hose from a 'high-rise' or wildland ('Cleveland'/Gnass) 'Bundle'. Or the last 100' of hose of any (properly) prepared coil configuration pre-connect a firefighter must pull to advance from the location in which a hose bundle is simply dropped on the ground and CHARGED! No matter where the 'Bundle' is placed during the deployment process, only the hose necessary from that drop point will ever be pulled.

Please view the demonstration at the one (1) minute mark in the online video at http://HoseRoller.net. Only AFTER walking around a parked car and then walking through one bay door, wrapping the post in a complete knot to exit a second/adjacent garage/bay door, thus fully wrapping the solid post between each, the hose is then FULLY charged. But with NO KINKS! This hose is then deployed to its full length in less than 40 seconds upon never pulling any more charged hose than what is ever needed from the moment the hose was pressurized up to its full length. And only ONE (1) firefighter doing the work of four… with a quarter (¼) of the effort… and in record time!

Any other hose-load configuration (Flat-Load, Triple-Fold, modified Minute-Man) with any tail whatsoever would immediately cease all forward progression at the first right-angle turn at the first rear tire of the car. But instead, I demonstrate an EFFORTLESS deployment that simulates advancing up to the point of entry into a burning building. A near-effortless advancement of fully charged line with full nozzle protection at every step of the way to a fire victim, while simultaneously creating an excellent indicator for emergency egress (follow the hose back to SAFETY) by the shortest distance out of the danger zone.

In other words, a hose 'bundle' that can be advanced DRY and with NO effort to a point at which water is EVER needed for the protection from and suppression of any fire AT ANY INCIDENT! As long as the hose is coiled to its 'Minimum Critical Inside Diameter' to prevent ALL kinks, it can then be fully pressurized in mere seconds from the moment its discharge valve is opened wide.

The ***BLUE LINE*** graph illustrates the amount of ***MOMENT EFFORT*** given as a percentage in effort/energy to simply advance/pull any hose at any one point in the deployment process given at a specific distance when comparing the 'Bundle' method vs. that of a folded/rolled method. The ***BOLD*** example upon advancing **30' of 'COILED' hose [*YELLOW BARs in a triangular illustration*] is *46%* of the effort to pull the same charged hose, but because it is folded or always rolled to have at least a 50' tail, it is compared to the 65' length of folded/rolled hose** [***BLUE BAR***] that is being dragged at that 30' foot distance from the point at which the hose was first charged.

The ***MAGENTA LINE*** graph illustrates, as a percentage also, the comparison of ***'TOTAL'* EFFORT OF THESE COMPARED HOSE ADVANCE** evolutions of the Coiled 'Bundle' Method vs. that of the folded/rolled method from the point of commencement. The coiled method at 2' feet is 4% of the moment effort, at 10' feet it was 18% of the moment effort, at 20' feet it was 33% of the moment effort, and at 30' feet it is 46% of the moment effort…

…but what is key is the TOTAL EFFORT from start to finish. The TOTAL EFFORT of the entire evolution, when you measure the SURFACE AREA under all* YELLOW BARS, *compared the SURFACE AREA under all the

corresponding BLUE BARS, it is then, therefore, evidenced the TOTAL EFFORT from zero (0') to 30' only 26%!

The video at **http://HoseRoller.net** [and **http://HoseCabinet.com**] demonstrates that one firefighter can do the same work as four (4)… in one quarter (¼) the time… and a quarter of the effort… and with absolutely NO water restrictive kinks EVER! The graph above is the mathematical evidence that this evolution of deploying hose from a coil configuration is exactly as all claims are demonstrated far more efficiently than most could ever imagine!

The choice is yours! Fold that long flat stuff on that horse wagon… that motorize cart… that $750,000.00 PIERCE! Are you such a traditionalist that you cannot be open-minded to what technology mathematically proves!?! Truly, is there any other method that produces such an incredible calculated and documented result… EVER!?!

About the Author

Richard William Hoffmann, Sr., is not only the creator of the world's first-ever seven (7) variable Excel spreadsheet to complete any Engine Pressure (EP) calculation in the Standard wildland hoselay configuration but has now created both the Android and iOS phone apps and the mechanical slide-rule that can be utilized in the field in REAL-TIME. These tools are able to solve the incredibly complex mathematical calculations for the sole purpose of establishing and maintaining an effective fire stream based on predictable and irrefutable laws of physics that have not been disputed in well over the past century.

Mr. Hoffmann mastered this process in a manner that anyone in the field with a basic understanding of Fire Hydraulics (Fire Engine Pump Pressure Calculations) can employ this technology. He has also invented one of the world's first-ever portable fire hose rollers that actually fits in nearly any compartment of a standard fire apparatus. Every length of dry and flat fire hose rolls up from a 50' ft. length of ¾" "Peanut Line", graduating through the attack-lines clear up to a 100' ft. length of Agnus 5" LDH weighing upwards of 125 lbs. or more!

The hose roller allows for a dual function that rolls fire hose both in a single or double 'donut' roll AND coils dry empty fire hose to it's 'Critical Minimum Inside Diameter'. This allows any attack-line or 'pre-connect' to be instantly charged and deployed in a matter of seconds and within mere feet from the rig… to provide a level of Firefighter SAFETY like no other hose deployment method ever attempted at any other time in Fire Service history. Please enjoy the video at http://hoseroller.net. The Dean of Students of the Fire Science Division of Texas A & M University requested the copyright of this online video to teach EVERY firefighter, up through the ranks of all command staff, who walks through their doors since 2006.

This video has over 128,000 international hits. Mr. Hoffmann has received countless correspondence from firefighters from five continents asking, ***"How in the world did you ever figure out such a (SIMPLE-STUPID) method anyway?*** The answer… by utilizing simple laws of physics that most firefighters have taken for

granted since implementing 'garden hose' technologies as a child just as I did when I was instructed to fill my doggy's water bowl at age five (5). May I, therefore, ask the simple question,

"***Would you ever fold a garden hose?"*** **If not, WHY NOT!?! …cuz it don't flow water no more!"**

A picture is worth a thousand words… what's a video demonstration worth to you!?! Especially if you KNOW it can save your life! Yes, 500 gallons on board, flowing at full pressure in a matter of seconds… within mere feet from your apparatus… three (3) pre-connects deployed simultaneously from three (3) personnel… able to fight fire at full nozzle pressure… at any distance from the engine up to the full length of deployment… up at risk or engaged in a full-force burn-over… more accurate than an air-tanker or helicopter drop… therefore able to protect our personnel… our greatest resource… at every step of a secured safe egress. **[http://BurnOver.HFTFire.com** as seen at **http://HoseRoller.net]**

Additionally, he is the first person on the planet to invent the world's first-ever functional fire hose cabinet design and deployment method. Due to family priorities, this project has been on hold since 2014 and is still waiting to be approved by the National Fire Protection Association as Underwriter Laboratory certified fire protection equipment. It will then be submitted to our nation's Senate and Congress to be mandated nationwide as the ONLY acceptable methodology and design… in an industry shut down since 2001:

ALL other designs have failed to deploy immediately within confined space at FULL nozzle pressure in mere seconds. The NFPA BANNED all models and design methods indefinitely as a FALSE SENSE OF FIRE PROTECTION [leaving many victims in the wake] only three (3) and a half months before his first patent issued in April of 2001. Please go to **http://HoseCabinet.com** to understand this incredible breakthrough also!

Mr. Hoffmann has since been able to modify his hose roller to fully function as an Eight-to-One (8-1) mechanical advantage Rope Rescue Winch [**http://RescueWinch.com**]. With this, rescuers can lower (belay) up to four (4)

rescuers and two (2) Stokes rescue baskets complete with all gear to a vehicle that has careened off a 150' foot cliff. Each victim can then be securely strapped in and safely raised to an awaiting helicopter long before their '*Golden Hour*' has expired. The work is accomplished in that 50 pounds of effort (torque) yields 400 pounds of work (lift). Never before has a piece of apparatus been this innovative to transition from hose roller to a rescue winch in seconds for fire and rescue personnel in Fire Service history!

On his time off, when he is not enjoying the beach with the awesome company and those who have valiantly supported him through one incredible trial after another, he applies his creative side by rendering spectacular photographs into even more spectacular digital paintings. In June 2011, he was one of the featured artists at the Ankeny Art Center, Ankeny, Iowa. Please enjoy his work on a YouTube video playlist at: **http://RHPhotographics.com**

It is genuinely Mr. Hoffmann's desire that all of these many inventions will make a huge difference for Firefighters and First Responders who put their lives on the line to serve. Mr. Hoffmann looks forward to hearing from you and would love to receive any feedback whatsoever.

"In honor of all five (5) of my kids and those who have supported me during this past GOD DESTINED six (6) years of incredible challenge, perseverance, and heartache on levels I would never wish on anyone ever. Yet this book, the Android and Apple (iOS) Phone Apps and the mechanical Slide-Rule and the other accomplishments yet revealed, would never have been possible. You know who you are as my biggest support, as demonstrated through thick and horrifically thin to endure it all! For you, especially, my love will never cease!"

June 10, 2014 at 7:06 pm at Portland International Airport