Water Supply Considerations When Pumping To Ladder Pipes

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Recent fires in the City of Dallas have revealed an opportunity for us to develop stronger tactics during defensive operations - i.e., when we are flowing ladder pipes. This is a chance to increase our skill set and address problems that have precluded us from accomplishing the mission we've been charged with — to save lives and protect property.

Before we continue, we need to establish some essential guardrails to this conversation. These considerations are limited to how they address the problems identified below. They carry little to no significance at fires where 1) hand lines are used for extinguishment or 2) when hydrants are within 100-200' of the attack engine. Further, these considerations are only that… "considerations." I aim to equip Driver Engineers, Officers, and Incident Commanders with a framework for understanding and solving issues in water supply at larger fires.

Identifying The Problem

"We're [running] out of water" is a frequent radio transmission at larger fires in which we have gone defensive and are now utilizing ladder pipes or multiple master streams to gain control of the fire. With each line that goes into service, our Driver Engineers monitor their compound gauge, watching it drop closer and closer to that "line of no return" — 20 psi. As our ICs call for more water or bigger lines to be put into service, our Driver-Engineers must determine whether or not they have enough water to supply the request. If it pushes them under 20psi on their intake gauge, most will "tap out" (correctly) and notify the IC that they cannot fulfill their request.

It's only after the fire, once we've picked up all the hose and returned to the station, that we might be asking ourselves if there was something else we could have done differently to get more water.

> *— Were we really out of water?*
>
> *— Did we really "bleed that hydrant dry?"*
>
> *— If we were to walk into the house or building next door and open a faucet, would water have come out?*

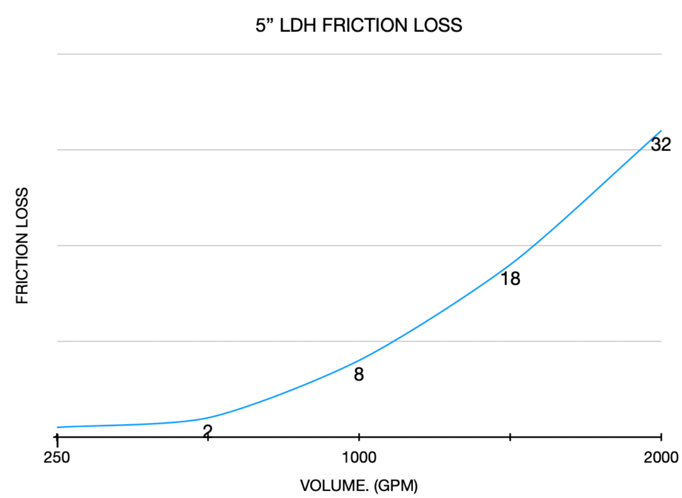
What I am proposing here is that the answer to these questions is that we were NOT out of water. In fact, we had plenty of water still "in the ground" to utilize. Further, If we had walked next door and opened a faucet, water indeed would have come out, just as it usually would.

Our most significant issue at these fires is typically NOT that "we've run out of water" at the hydrant. Instead, our issue is that the water coming from our hydrant has slowed down due to friction loss in our supply hose and therefore cannot match our desired output. We're simply not bringing water into our engines fast enough to flow the desired volume of water necessary.

So, what is causing this to happen?

The issue is in our 5" supply hose. More specifically, it is due to the friction loss generated inside that 5" supply hose, as large volumes of water are being forced through more than four sections of hose. It is important to remember that friction loss is volume-dependent. The greater the volume, the greater the friction loss. Conversely, the lesser the volume, the lesser our friction loss.

5" hose is bragged on by manufacturers and even highlighted in our rookie school IFSTA books as hose with minimal or "next to nothing" friction loss. This is true, *but only at lower volumes*. For example, when we are flowing under 500 GPM, the friction loss in 5" hose IS next to nothing, equating somewhere between 1-2psi per 100'. However, as the figure to our right shows, once we move past 1,000 GPM the friction loss we experience begins to increase rapidly.



Pressure and Velocity

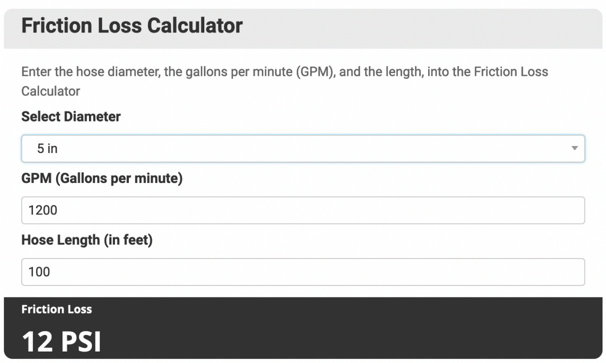
Our Engine's pump is designed to impart velocity to the water it receives. Water comes in… our pump speeds it up… and it is spit out the discharge side. On our pump panels, though, we don't have a feet-per-second gauge; instead, we measure a byproduct of that velocity, pressure. Pressure is the measurement we can capture and visualize on our pump panels. This is why we don't regularly talk about the "speed of water," but rather the pressure in our pumps, hose, etc — because pressure is what we see on the gauge, not velocity.

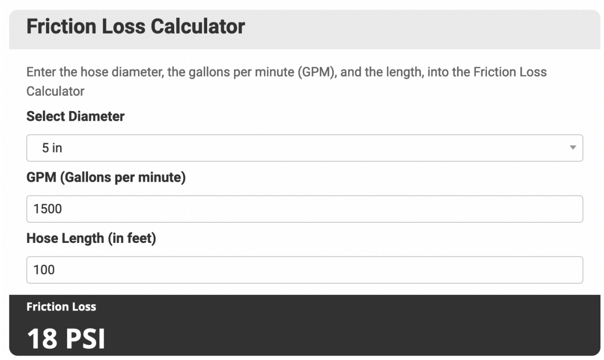
But don't let that misguide you. Velocity, or the speed of water, is the critical issue when we are battling larger fires that require ladder pipes. The issue is that our water is slowing down before it hits our pumps due to the friction loss in our 5” supply hose. We can see this on our intake/compound gauge as it bottoms out, and we’re left telling the Chief, “we’re out of water.”

But the reality is… we haven’t run out of water. Rather, ***our water has slowed down too much!***

Friction Loss Is Slowing Us Down

Let’s move a bit more granular and consider what our friction loss in 5” LDH is when we are flowing 1,200 and 1,500 GPM:





Armed with these facts, let’s consider what our hydrants are producing in terms of pressure and how this friction loss in our LDH impacts (or slows down) our water supply.

Most hydrants in the City of Dallas provide somewhere between 60 and 90 psi at the hydrant. Now, as we can see in the chart below, once we start flowing ladder pipes (~ 1,200 GPM), the friction loss on the intake side of our pumps (what is between the hydrant and our engine) starts to run away from us, increasing to the point that the pressure our hydrant was initially supplying us with is now, wholly negated.

5” LDH	FL @ 1,200 GPM	FL @ 1,500 GPM
Friction Loss >>>>	12	18
100	12	18
200	24	36
300	36	54
400	48	72
500	60	90
600	72	108
700	84	126
800	96	144

** Friction Loss in 5” LDH at 1,200 and 1,500 GPM*

Now consider this… If we have 500’ of 5” LDH on the ground, being supplied by a 60psi plug that is flowing 1,200 GPM, our intake gauge will be dang close to 0psi. Most Driver-Engineers do not feel comfortable, and rightly so, running at this pressure and will opt to either under-supply the ladder pipe so that they can maintain at least 20psi on their intake gauge or radio the IC that they cannot supply the Truck at all.

60psi (hydrant)
- 60psi (friction loss in 500’ of hose)

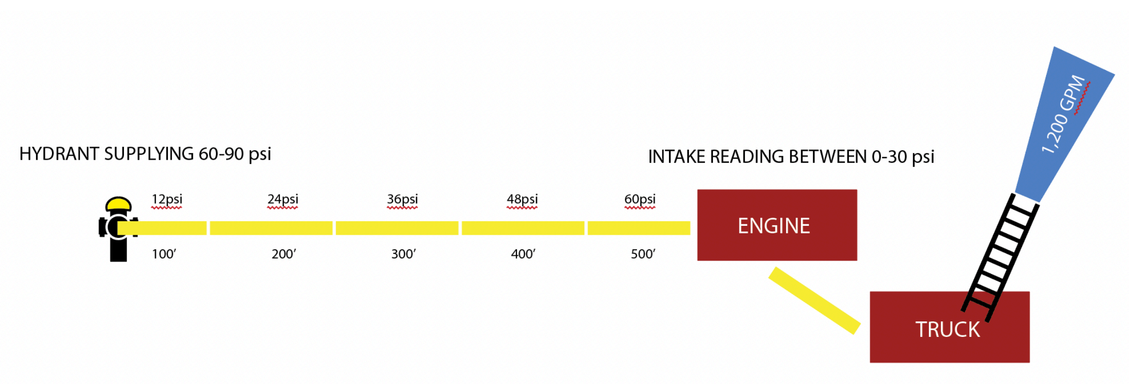
= *0 psi at your intake gauge*

Now, if the hydrant is putting out closer to 90psi in this scenario, our intake gauge will sit somewhere closer to 30 psi. This situation is much better than the previous, but also leaves little room for additional lines to be put into service and will cause most Drivers to again radio, “We don’t have enough water to supply that,” when the IC calls for additional exposure lines.

90psi (hydrant)
- 60psi (friction loss in 500’ of hose)

= *30 psi at your intake gauge*

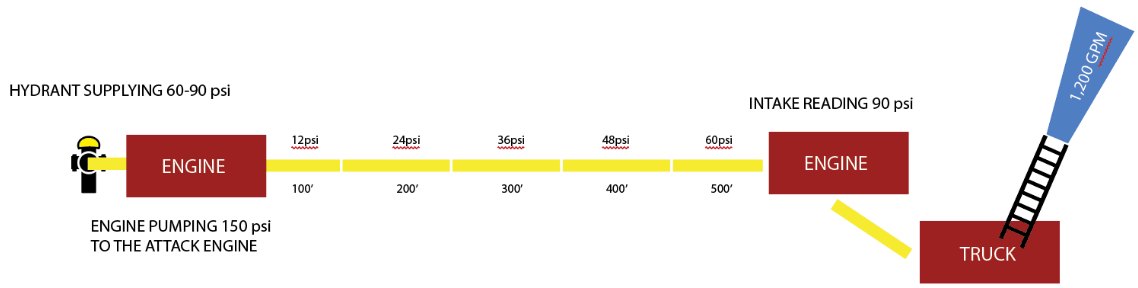
Clearly, the issue is that friction loss is slowing our water down when we try to put 500’ of supply hose between our engines and the hydrant.



So, if the issue is that our water is slowing down due to excessive friction loss in our supply hose, what is the solution?

The solution is to <u>speed up the water!</u>

How do we speed the water up? The answer is to place an Engine as close to the hydrant as possible and pump to the attack engine supplying our Ladder Truck. In doing this, we are increasing the speed of our water, which translates onto our pump panel gauges as pressure.



This process is called "pumping off the hydrant" and allows us to move the hydrant right next to the attack engine effectively. We're adding a "pressure margin" to the attack pumper so that when we begin pumping to our ladder pipe, the water still has plenty of speed coming in to supply not only the ladder truck but several other lines potentially.

Putting It Into Action

If we are going to proactively address this potential problem at working fires that require defensive operations and the use of ladder pipes, we need to develop strong water supply tactics from the onset. For our Chiefs, Officers, and Driver-Engineers, any time we are anticipating the use of ladder pipes, we should set up *from the start* by placing an engine at the hydrant.

The most reasonable way to accomplish this would be to have the second AND third due engines stage at the same hydrant. Our current MOP (601) outlines that the third due engine will stage at a secondary hydrant. If however, the third due engine deviated and "backed up" the second due engine, the second engine could lay in as usual, only without connecting to the hydrant. The third engine would pull up and make all the connections, placing themselves between the hydrant and the attack pumper(s).

Practically the steps in accomplishing this would look something similar to:

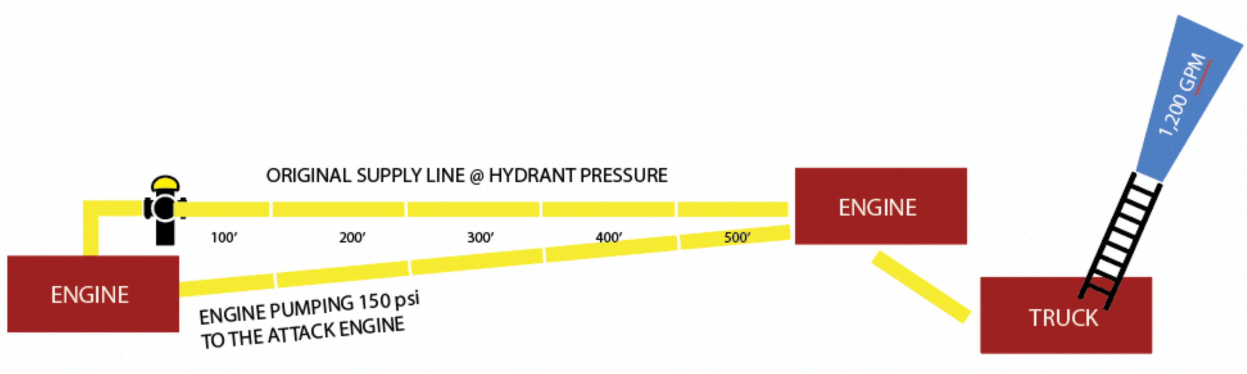
1) First due engine would proceed directly to the fire and deploy resources as seen necessary by the IC and call for water.
2) The second due engine would initially stage by the closest, appropriate hydrant. While waiting for the first due engine to call for water, a member from the engine would exit the apparatus, wrap the hydrant, and connect the in-line gate valve to a side discharge and flow water to ensure that we have a working hydrant. They ***WOULD NOT*** make any hose

connections to the hydrant and subsequently lay in once the call is made for water by the first due engine Officer.

3) The second due engine would lay in to the first due and “dump their tank.”
4) While the second due engine is laying in, the third due engine would move up to the hydrant that was wrapped and dressed with the hydrant valve and connect the main steamer discharge to one of their keystones. The supply line that was laid by the second engine would then be connected to one of their discharges. Once the permanent connection was made, the third due engine would start by pumping 150 psi to the second due engine, who is then supplying the first due company in series.
5) With these steps accomplished, the third due engine should establish a minimum of one additional 5” supply line into their apparatus by utilizing the 3-to-5 inch increaser.
6) In continued efforts to create a system of redundancy, at least one 5” supply line should be connected between the first and second due engine (or dual 3” supply lines). Note these should be hooked up in series, discharge-to-intake. If *additional* redundancy is desired, a supply line can be hooked up intake-to-intake (dual pumping) between the first and second due, but only after the discharge-to-intake lines have been secured.

Plan B

Let's assume that, for some reason, the first due IC misjudged the potential need for defensive operations that require ladder pipes. Because the second due engine was called to "bring water" and utilized a forward lay that was greater than 250', we need to have a Plan B so that we can still implement "big water tactics." The second due engine will almost assuredly not be part of this solution. Therefore, as command is passed and the need for ladder pipes is recognized, we must notify the third due or RIT engine that they must reverse lay back to the hydrant. Once this has been accomplished, they will need to connect to the hydrant's side discharge via the inline gate valve and the 3-to-5" increaser in the plug kit. A second 5" supply line is then connected from the hydrant to the supply engine which is then pumped back to the fire ground's attack engine. You will now have the original 5" supply line that the second due laid in AND the additional 5" line that was reverse laid.



Is this Plan B the optimal solution? Not really, but it's a dang good one that allows us to keep some water flowing and prevents us from having to shut down altogether.

Table 4.12.1(a) Theoretical Discharge Through Circular Orifices (U.S

Pitot Pressure (psi)	Feet	1.75	2	2.25	2.375	2.5
1	2.31	91	119	151	168	187
2	4.61	129	169	214	238	264
3	6.92	158	207	262	292	323
4	9.23	183	239	302	337	373
5	11.54	204	267	338	376	417
6	13.84	224	292	370	412	457
7	16.15	242	316	400	445	493
8	18.46	258	338	427	476	528
9	20.76	274	358	453	505	560
10	23.07	289	377	478	532	590
11	25.38	303	396	501	558	619
12	27.68	317	413	523	583	646
13	29.99	329	430	545	607	672
14	32.30	342	447	565	630	698
15	34.61	354	462	585	652	722
16	36.91	366	477	604	673	746
17	39.22	377	492	623	694	769
18	41.53	388	506	641	714	791
19	43.83	398	520	658	734	813
20	46.14	409	534	676	753	834
22	50.75	429	560	709	789	875
24	55.37	448	585	740	825	914
26	59.98	466	609	770	858	951
28	64.60	484	632	799	891	987
30	69.21	501	654	827	922	1022
32	73.82	517	675	855	952	1055
34	78.44	533	696	881	981	1087
36	83.05	548	716	906	1010	1119
38	87.67	563	736	931	1038	1150
40	92.28	578	755	955	1065	1180
42	96.89	592	774	979	1091	1209
44	101.51	606	792	1002	1116	1237
46	106.12	620	810	1025	1142	1265
48	110.74	633	827	1047	1166	1292
50	115.35	646	844	1068	1190	1319

One issue that I anticipate being levied against this sort of Plan B is that the side discharge won't supply enough water for our 5" since it is only 2.5". I understand this concern; however, under pressure, a 2.5" discharge can supply roughly 80% of what the front 4" steamer can supply.

As you can see from the chart to our right, at 50psi the side discharge of our hydrants can theoretically produce over 1,300 GPM.

Conclusion

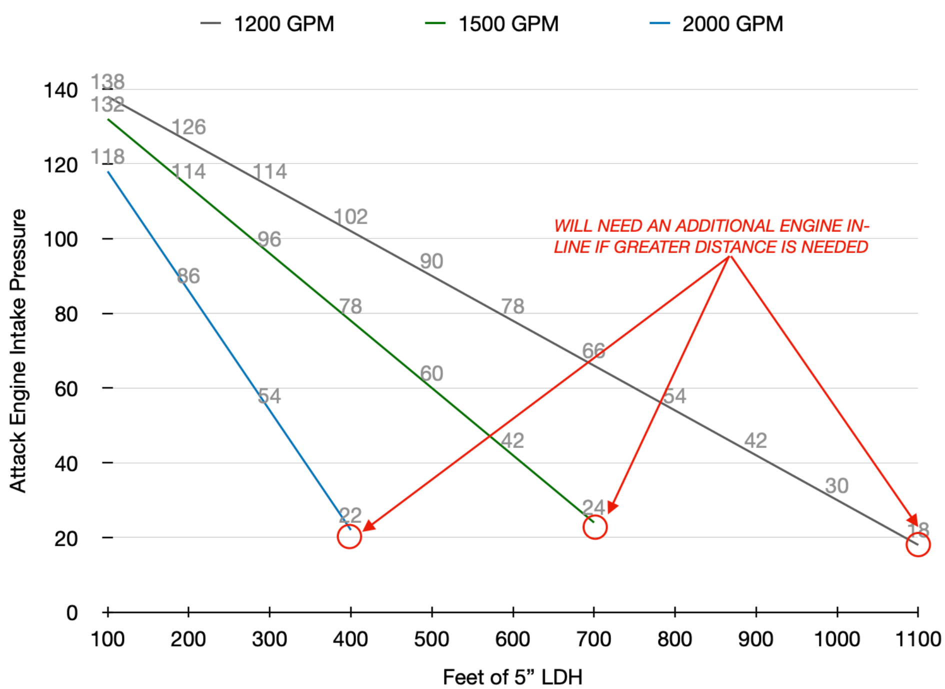
In conclusion, where we typically run into issues that result in our Driver-Engineers saying that "we're out of water" is when we lay more than 400' of 5" supply hose and then expect to supply ladder pipes effectively. The friction loss on our supply hose slows the water down before it reaches our pumps, causing the intake gauge to read somewhere between 0 and 30 psi typically (depending on the initial pressure from the hydrant and other factors).

The solution is that we need to speed up our water when we anticipate the use of ladder pipes. We do this by putting an engine as close to the hydrant as possible (within 100') and pumping to our attack engines so that we overcome the friction loss in our supply hose. The engine at the hydrant should be placed in "volume mode" and discharge at a minimum 12 psi per section of 5" between them and the attack engine supplying the ladder pipe. If drivers want to keep things simple, I would start at 100-150psi. They should never exceed 190psi, as this is the working limit of the LDH we utilize. It should also be noted that our engines are equipped with pop-off valves at the intake side of our pumps that do not allow greater than roughly between 190 and 210 psi, depending on the apparatus.

The issue is our water is slowing down. The solution is to speed it back up, after all, our engines are called "pumpers" NOT "suckers" for a reason. Let's start pumping and stop sucking.

Appendix A - Functional Working Distance

The following chart provides additional information on the functional distance we can move water with an engine at the hydrant pumping 150psi. The Y-Axis denotes the attack pumpers compound gauge when supplied by an engine at the hydrant with a PDP of 150psi. The X-Axis denotes the distance we can effectively push water before the attack pumpers compound gauge shows 20psi.



FUNCTIONAL DISTANCE WE CAN MOVE WATER WITH 150PSI AT THE HYDRANT

As the above chart indicates, the maximum functional distance we can move larger volumes of water with an initial hydrant pressure of 60psi are:

- **1,200 GPM** = *1,100 feet before we would need to place another engine in-line to achieve greater distances.*
- **1,500 GPM** = *700 feet before we would need to place another engine in-line to achieve greater distances.*
- **2,000 GPM** = *400 feet before we would need to place another engine in-line to achieve greater distances.*

I want to make sure to note that there are issues that could arise due to unforeseen variables, causing all our theoretical numbers to run a fowl. For example, the size of hydrant's main and the condition of the main itself could cause volume and pressure loss to some degree. This would directly affect the working distance we could move water as modeled above. Do I anticipate this being a common issue we run into? No. But, I suppose it is possible that we find an old silver top with years of calcification and/or other damage that significantly throttles our available volume and pressure. My experience is that this is possible, but not likely.

Appendix B - Heavy Hookups

"Heavy Hookups" is a term used to denote the utilization of multiple supply lines off of a SINGLE hydrant, and into a SINGLE engine.

Our apparatus in Dallas are equipped with 4 accessible intakes:

- *Two, 5" Keystone*
- *Two, 2.5" Pony Suction*

By utilizing two or three hydrant discharges we can capture the maximum amount of volume and velocity from our hydrants. The following picture details what a "heavy hookup" would look like at the hydrant.