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Rural Fire Command

by

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Fluid Motion, Part 2

Losses in Suction Piping

RFI

RURAL FIREFIGHTING INSTITUTE

Training America's Rural Fire & Emergency Responders

A Message the Author, Larry Davis

In October 2002, I started writing the monthly "Rural Fire Command" column for *FireRescue Magazine*. Since that time, the RFC column has been carried in just about every subsequent issue of the magazine.

As time has passed, several readers have contacted me about obtaining back issues of the column. Some expressed an interest in acquiring the articles in Powerpoint format for use in training programs.

This led to, my adaptation of the RFC columns to the PowerPoint format. These PowerPoint programs are being made available through the combined efforts of *FireRescue Magazine* and the Rural Firefighting Institute.

Fluid Motion — Part 2
Losses in Suction Piping

In last month's issue, I covered the factors that affect drafting operations—altitude, water temperature, static lift and maximum usable pressure (MUP).

In this issue, I'll look at how intake losses due to friction impact drafting operations, (which will identify any problems that reduce delivery rates), and what you can do to increase flow.

When needed, drafting operations must provide the highest delivery rate possible. It's the little things that can make or break a firefight, so by evaluating your equipment and Standard Operating Procedures (SOPs) now, you can significantly increase pump output and delivery rates when drafting, which will maximize your existing resources' fire-stopping power. In this issue, I'll focus on suction piping to midship pumps.

The Heart of the Pump

When drafting with a fire pump, the pump impeller maintains a partial vacuum; any restriction between the static water source and the impeller impedes water flow, such as friction losses in suction hose, strainers and intake piping.

The impeller is the heart of the fire pump. It can only discharge the volume of water that we allow to enter it, which is why it's so important to minimize the length of hard suction hose and apparatus suction piping between the static water source and the pump impeller.

The shorter the combined length of suction hose and piping, the shorter the distance water has to travel to reach the impeller eye, the lower the friction losses, and the higher the delivery rate from the pump discharge—this is a key factor in a pump's ability to move water and stop a fire.

Pressure Losses Due to Flow

At the very least, drafting operations require suction hose (hard sleeve) and a strainer. In the last installment, I discussed pressure losses under static (no-flow) conditions.

Once water starts moving through the suction hose and strainer, it encounters friction loss.

Figure 1 shows pressure (friction) losses in suction hose.

Figure 2 shows pressure (friction) losses in suction strainers.

The values in these tables can be used to determine friction losses at any desired flow.

Friction Losses in Suction Hose & Strainers

Friction Loss (psi) per Foot of Suction Hose

Flow	4-1/2"	5"	6"
100	.01	.001	.000
200	.01	.003	.001
250	.01	.004	.002
300	.01	.006	.002
400	.02	.010	.004
500	.03	.016	.007
600	.04	.023	.009
700	.05	.032	.013
750	.06	.036	.015
800	.07	.041	.017
900	.09	.052	.021
1000	.11	.065	.026
1250	.17	.101	.041
1500	.25	.145	.059
1750	.33	.198	.080
2000	.44	.258	.104
2250	.55	.327	.132
2500	.68	.404	.163
2750	.82	.489	.197
3000	.98	.581	.234

Figure 1

Friction Loss in Suction Strainers

Flow	4-1/2"	5"	6"
100	.03	.02	.01
200	.12	.08	.04
250	.18	.12	.06
300	.26	.17	.08
400	.46	.30	.15
500	.73	.48	.23
600	1.04	.68	.33
700	1.42	.93	.45
750	1.63	1.07	.52
800	1.86	1.22	.59
900	2.35	1.54	.74
1000	2.90	1.90	.92
1250	4.53	2.97	1.43
1500	6.53	4.28	2.07
1750	8.88	5.82	2.81
2000	11.60	7.60	3.67
2250	14.68	9.62	4.65
2500	18.13	11.88	5.74
2750		14.37	6.94
3000		17.10	8.26

Figure 2

Suction Piping Losses

Just as there are pressure losses in suction hose and strainers, so too are there losses in any suction piping added to the pump in the form of front and rear suction connections to midship pumps.

Figure 3 shows the friction losses per 100 feet of 4", 5" and 6" pipe.

Figure 4 shows the equivalent lengths of various fittings used in these same diameters.

Suction Piping Losses

Friction Loss (psi/100 ft) of Pipe

Flow (gpm)	4"	5"	6"
200	1.3	.4	.2
250	2.0	.7	.3
300	2.1	1.0	.4
400	2.8	1.6	.7
500	3.9	2.5	1.0
600	10.2	3.4	1.4
700	13.4	4.6	1.9
750	15.4	5.2	2.1
800	17.4	5.9	2.4
900	21.6	7.3	3.0
1000	26.3	8.8	3.6
1050		9.6	3.9
1100		10.6	4.3
1200		12.4	5.1
1250		13.4	5.5
1300			5.8
1400			6.9
1500			7.7
2000			11.7
2500			17.7

Figure 3

Equivalent Length (ft of pipe) of Fittings and Valves

	4"	5"	6"
45□ Elbow	4	5	7
90□ Standard Elbow	10	12	14
90□ Long-Turn Elbow	6	8	9
Tee or Cross (flow at 90□)	20	25	30
Gate Valve	2	2	3
Butterfly Valve	12	9	10
Swing Check Valve	22	27	32

Equivalent Pipe Length Chart (source: *Fire Protection Handbook*, 18th ed.)

Figure 4

Front & Rear Suctions

Figure 5 shows a typical full-size urban engine with a midship fire pump equipped with a front suction connection—a common option available from most fire apparatus manufacturers, and one frequently selected by urban departments that routinely take suction from hydrants with preconnected soft suction hose.

Figure 5. An urban engine with a typical front suction and a preconnected 5" supply line.

Front & Rear Suctions

Today, we see more and more rural departments opting for front suctions as well.

Figure 6 shows a rural engine with a short length of hard suction and low-level strainer preconnected to a front suction for porta-tank drafting.

While some departments opt for rear suctions, front suctions are much more common because the driver/operator can quickly and easily spot the pumper so a preconnected soft suction hose can be connected to a hydrant to get water into the fire pump.

Figure 6. A 6' length of suction hose is better than a 10' length, but the water still has to travel through about 100 feet of pipe to get to the pump.

One might say that the apparent convenience of a front suction is similar to that of a 1" booster line on a reel. While both are time-savers, the price paid for this convenience amounts to a severe limitation in delivery rate because front or rear suctions impose flow restrictions to the fire pump during both drafting and hydrant water-supply operations.

Hydrant operations generally have sufficient hydrant pressure to help overcome the additional friction losses in front and rear suction intake piping, but in drafting operations, no matter how you slice it, the pressure available to push water into the pump is limited to the maximum usable pressure (MUP).

Figure 7 shows a side view of the engine shown in ***Figure 5***. As you can see, the distance between the front suction connection and the centerline of the midship pump equals 17 feet—a relatively short distance.

Figure 7. A side view of the Corpus Christi (Texas) engine with front suction and a preconnected 5" supply line in front bumper. The straight line distance from the front suction connection to the pump is 17 feet.

Unfortunately, the actual length of the pipe and fittings required to run the front suction piping from the connection, over and under different parts of the apparatus, and into the pump is much more than 17 feet.

In addition, because of where the manufacturer has to run the piping, it measures 5" in diameter rather than 6". The worst place they jockey the pipe is between the underside of the cab and the front axle. Some manufacturers use rectangular tubing while others cut pipe for a D-shaped section to run here.

When you get a chance, check out the front suction piping on a cab-forward chassis and see if you can find any shiny spots on the piping above the axle. These are due to the right tire rubbing against the pipe — this can't be good for either the tire or the pipe!

Figure 8 shows a diagram of the piping and the tally sheet for the front suction's total equivalent length. What's amazing is that the engine is about 35 feet long, but the water has to travel *over three times that length* from the front suction connection to the pump.

Piping and Fittings in the Front Suction Piping

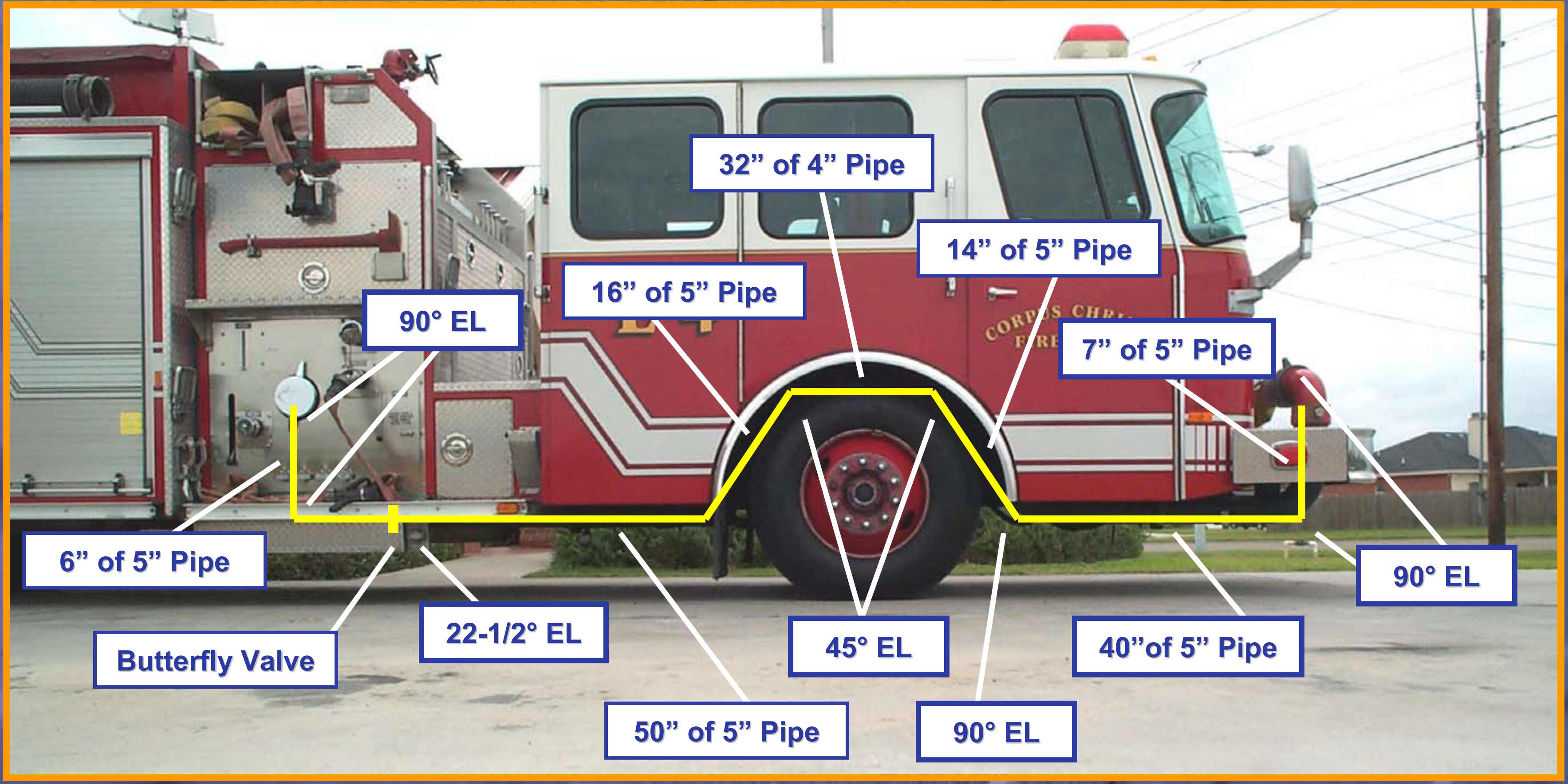


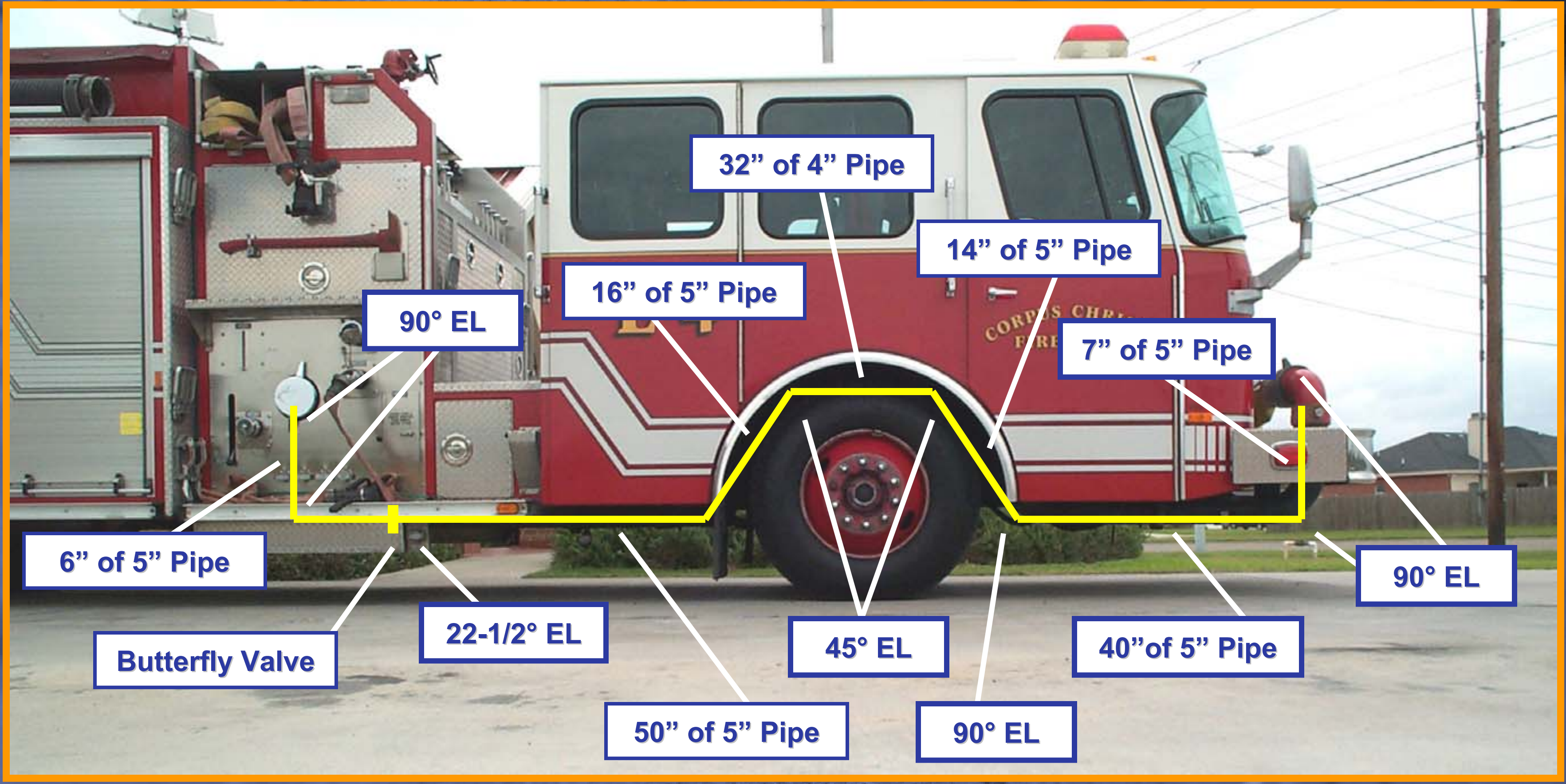
Figure 8. The piping and fittings used to pipe the front suction on this Corpus Christi engine’s front suction.

Figure 9 shows how the equivalent length of piping in the front suction is calculated.

When we total the length of each piece of pipe, and the equivalent lengths for each of the fittings (elbows and valves) in the 5" suction piping, we find the front suction has a total equivalent length of 106 ft of 5" pipe. And, of course, this extra piping generally costs the buyer between $5,000 and $6,000.

What does this mean as it relates to the drafting performance of a rural fire department? When a 1250-gpm engine uses its front suction (106 ft of 5" pipe) and 20 ft of 6" suction hose with a 10-ft lift, it has a maximum predicted performance of only 600 gpm.

<u>The price paid in performance for the convenience of having a front suction is a reduction in pump output of 52%</u>.



5” Pipe = 7” + 40” + 16” + 50” + 6” =133” or 11.1 ft

4” Pipe = 32” or 2.7 ft (conversion to 5” = 3.1 x 2.7 ft) = 8.4 ft of 5” Pipe

5” x 90° ELs = 5 x 12 ft/EL = 60.0 ft

5” x 45° ELs = 3 x 5 ft/EL = 15.0 ft

5” x 22-1/2° EL = 1 x 2.5 ft/EL = 2.5 ft

5” Butterfly Valve = 1 x 9 ft/valve = 9.0 ft

Total Equivalent Length of 5” Suction Piping = 106.0 ft

Figure 9. Equivalent length of piping in front suction.

Side Suctions

Let's look at an alternative operation: The pumper is nosed into the water supply, the engineer uses a side suction instead of the front suction and an additional 20 ft of suction hose (40 ft total length). With a 10-ft lift, the maximum predicted performance of our drafting operation increases to 1190 gpm, or 95% of rated pump capacity.

Figure 10 shows how you can use a side suction to draft from the front of an apparatus.

So, with all other conditions remaining the same, using a side suction and 40 ft of suction hose instead of the front suction produces a 590-gpm gain in water delivery capability—that's almost a 100% increase in drafting performance!

With today's lightweight, flexible suction hose, a pumper can still nose into the draft site and use a side suction to draft. And for the cost of one front suction, we can buy 5 or 6 lengths of suction and run dual side suctions.

Figure 10. How to use a side suction to draft from the front of an apparatus.

Polson Front and Side Suction Tests

In September 2004, during a Water-on-Wheels course in Polson, Montana, I had the opportunity to compare a 1250-gpm pumper's front suction to its side suction. The test results were:

- The front suction delivered 800 gpm
- The side suction (using 40 ft of suction hose) delivered 1307 gpm.
- Using the front suction (20-ft of 6" hose) and a side suction (40-ft of 6" hose) delivered 1680 gpm

We later used this pumper as a fill site to fill tankers as a part of an ISO tanker delivery test. We did not use the front suction. As a result, the 3-tanker operation maintained an 800-gpm delivery rate over a 1-mile course. If we had used the front suction, we would never have reached the 800-gpm delivery rate.

While a front suction can severely limit drafting operations, it also impacts water flow into a pump in a hydrant operation. But that's a subject for another day.

The Bottom Line

So, what's the bottom line? Should you avoid purchasing or using front suction connections? No. That's the prerogative of your department. But rural firefighters must be aware of the significant impact of suction piping and how it can work against them. Besides, you could probably use the $5,000 - 6,000 that a front suction costs to fund a larger-capacity pump.

If a department plans to use a front suction for drafting operations, they must know its maximum flow capability and be prepared to get a second suction or supply line into a side suction when the Command calls for more water.

A Final Word

Drafting operations are labor-intensive and require planning well in advance of the fire.

In the next installment, we'll continue our discussions of what you can do to maximize drafting output with minimum manpower, time and equipment.

In the meantime, take a look at the apparatus you have and the drafting operations you expect to use to see what total losses you can expect in suction hose, strainers, and any additional suction piping.

Special Thanks

Thanks to Chief Adame and the crew of the Corpus Christi (Texas) Fire Department's Engine 4, I had the opportunity to crawl under and around their front suction piping to measure each length of pipe and count the number of fittings installed within the front suction.

For Questions or comments on this or any of the Rural Fire Command articles, contact the author at ldavis@RFI411.org

About the Author

Larry Davis is a full member of the Society of Fire Protection Engineers, a Certified Fire Protection Specialist, and a Certified Fire Service Instructor II with more than 30 years experience as a fire service instructor. He is Vice President of GBW Associates, and Chairman of the Rural Firefighting Institute.

Davis has conducted more than 400 Rural Firefighting Tactics and Rural Water Supply Operations seminars throughout the United States and Canada. In addition, he has written numerous fire service texts, including *Rural Firefighting Operations*, books I, II, and III. Most recently, Davis co-wrote the *Rural Firefighting Handbook* and *Foam Firefighting Operations*, book I with Dominic Colletti.

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