e-TechNotes

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Hose Stream Demand, Fire Pumps and Water Supplies

The question is frequently asked about sizing a fire pump with a water supply and whether or not hose stream demand needs to be added. This question is sometimes framed as asking for a procedure to perform hydraulic calculations with a fire pump and hose stream demand. The answer is that there is no single procedure that can be used for performing hydraulic calculations because there are at least four different arrangements of equipment and two different goals/objectives that need to be simultaneously met. The four different potential arrangement of equipment are as follows:

1. System with sprinklers and hose connections inside the building, but no hydrants between the sprinklers and the pump.

2. System with sprinklers inside the building and hydrants outside the building, but still downstream of the fire pump.

3. System with sprinklers inside the building and no hose connections.

4. System with sprinklers inside the building and hose connections at the water supply or between the water supply and the pump.

The two simultaneous goals/objectives are:

A. Making sure the pump is sized correctly to meet the demand of whatever is downstream of the pump (see sections 11.1.5.3 and 12.8.2 in NFPA 13).

B. Making sure the water supply is capable of meeting the system demand (see section 23.1.2 in NFPA 13).

If you are taking the calculations to the pump discharge (which is the way we teach our classes here at the NFSA), and if you have equipment arrangement #2, both goals/objectives A and B can be met with the same hydraulic calculation procedure. In order to size the pump and water supply correctly in this circumstance, you need to use the following procedure:

1. Calculate the fire sprinkler system from the most remote sprinkler back towards the discharge flange of the pump. Since the system has inside hose stations, add 50 gpm at the connection of the two most remote inside hose stations to the sprinkler piping. Since the system has outside hydrants between the sprinklers and the pump, add the outside hose demand at the connection of the closest fire hydrant to the building when working back towards the pump.

2. Using the total sprinkler system demand flow for the fire protection system calculated in Step 1 (which might include some or all of the hose stream demand as described in Step 1), calculate the suction pressure that the water supply will deliver to the fire pump at the total demand flow. This will be the residual pressure (at the reasonable worse-case low point for the water supply) at the water supply (at the total demand flow) minus the friction loss of the demand flow going to the pump minus (or plus) the elevation change between the water supply and the pump. Note that this calculation needs to be done with the reasonable worse-case conditions of the water supply.

3. Select a fire pump so that the net pressure produced by the fire pump at the total demand flow

plus the suction pressure from the water supply at the demand flow equals or exceeds the pressure demand at the pump discharge flange. Note that the pump is permitted to be used at flows up to 150% of rated flow when making this determination.

4. Calculate the suction pressure at the maximum flow for the pump (usually 150% of rated flow) and make sure that it is a positive number. Note that this needs to be done with the reasonable worse-case conditions of the water supply.

5. Calculate the maximum pressure produced by the pump (at churn) and make sure it does not overpressurize the system. This is done by taking the static pressure at the water supply plus the churn (net) pressure of the pump and subtracting (or adding) the elevation change between the water supply and the pump. Note that this needs to be done with the reasonable high static pressure from the water supply.

The example below illustrates this procedure for an ESFR system with multiple hose stations inside the building and fire hydrants outside the building so that the entire flow demand of the sprinklers plus hose streams has to be calculated through the fire pump:

<u>Example #1</u>

An ESFR sprinkler system is designed with the following characteristics:

- A flow demand of 1350 gpm
- An inside hose stream demand of 100 gpm
- An outside hose stream demand of 150 gpm
- Total flow demand for this system is 1600 gpm (1350 + 100 + 150 = 1600)
- The pressure demand at the pump suction flange has been calculated as 120 psi
- The water supply in this case is a municipal water utility as shown in Figure 1
    - A reasonable worse-case static pressure of 50 psi
    - A reasonable worse-case residual pressure of 41 psi at 1600 gpm
    - From Figure 1, you can see a residual pressure of 33 psi at 2250 gpm
    - The reasonable high static pressure is 70 psi
- Suction pipe is 800 feet (including equivalent lengths of fittings and valves) of 8-inch lined ductile iron (I.D. = 8.27 inches)
- The elevation of the pump is 15 ft above the point where the water supply pressure was measured

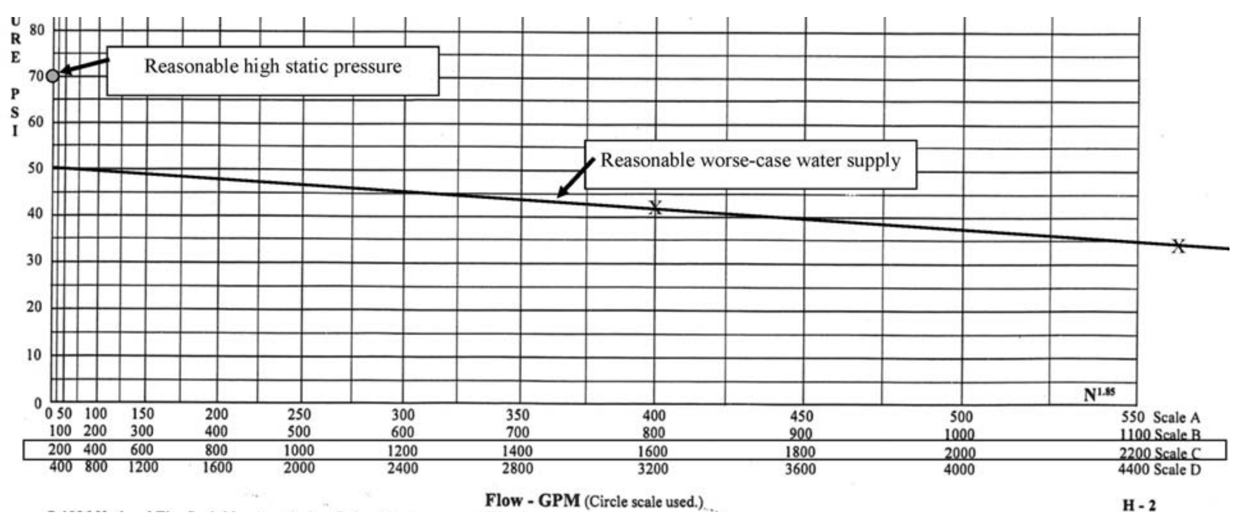


Figure 1 – Water Supply for Example 1

The steps for sizing the pump and water supply are completed as follows:

1. Done and reported to be 1600 gpm at 120 psi.
2. At 1600 gpm, the water supply has a residual pressure of 41 psi. The friction loss between the water supply and the pump is 11.1 psi (using Hazen-Williams). The elevation loss between the water supply and the pump is 6.5 psi (15 x 0.433 = 6.5). Therefore, the suction pressure at the pump is 23.4 psi (41 – 11.1 – 6.5 = 23.4) at the demand flow of 1600 gpm.

3. Don't consider any pumps rated at 1000 gpm because they could only supply a maximum of 1500 gpm, which is not enough for this example. Consider some 1250 gpm rated pumps, some 1500 gpm rated pumps and some 2000 gpm rated pumps. In the interest of keeping this discussion relatively short, let's say we found a pump rated at 1500 gpm and 105 psi. This pump curve (shown in Figure 2) has the following net pressure/flow combinations:

   a. 120 psi at churn (no flow)

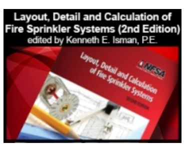
   b. 105 psi at 1500 gpm

   c. 101 psi at 1600 gpm

   d. 70 psi at 2250 gpm

4. At maximum flow (2250 gpm), the suction pressure at the pump will be 5.6 psi (33 – 20.9 – 6.5 = 5.6), which is acceptable because it is a positive number. Note that this keeps the pressure in the main at 33 psi during this flow condition, which is greater than the 20 psi required by most water utilities.

5. The maximum pressure created by the pump will be 183.5 psi psi (70 + 120 – 6.5 = 183.5). Note that this exceeds 175 psi, so pipe valves and fittings at the elevation of the pump and 20 ft higher will have to be rated for at least 183.5 psi. At the location 20 ft above the pump, the elevation loss drops the pressure below 175 psi, so standard sprinklers, pipe and fittings can be used above this elevation.



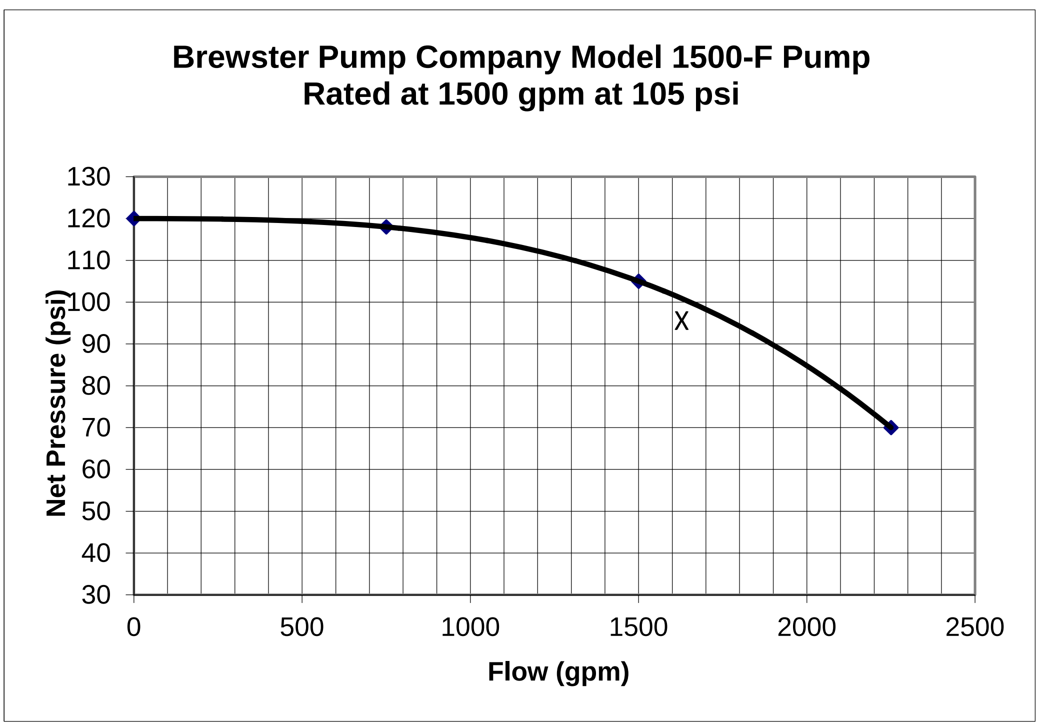


Figure 2 – 1500 gpm Fire Pump Used in Example 1

In this case, this fire pump and this water supply both meet all of the rules of the NFPA standards to supply this fire protection system (sprinklers and hose stream demand). When you add the net pressure of 101 psi to the suction pressure of 23.4 psi at 1600 gpm, the discharge pressure is 124.4 psi, which exceeds the pressure demand of the sprinkler system at 120 psi. Since the reasonable worse-case water supply was used to generate the discharge pressure, no additional safety factor is required.

The five-step procedure discussed above only works because all of the flow demand is coming through the pump. For this reason, it would work for equipment arrangement #3 since there would be no hose connections and therefore no hose stream demand in that case. You could use the five step procedure as discussed above with Step 1 slightly modified to include only the sprinkler system demand. For the other two equipment arrangements, some of the water will be taken from the water supply and used by the fire department without having the water go through the fire pump. The following modified procedure needs to be used to size the pump and the water supply:

1. Calculate the fire sprinkler system from the most remote sprinkler back towards the discharge flange of the pump. If the system has inside hose stations, add 50 gpm at the connection of the two most remote inside hose stations to the sprinkler piping.

2. Calculate the total flow demand by adding the outside hose demand to the sprinkler flow demand calculated in Step 1.

3. Using the total flow demand from Step 2, determine the residual pressure at the water supply when this total flow is being used. Note that this needs to be done with the reasonable worse-case of the water supply.

4. Calculate the suction pressure that the water supply will deliver to the fire pump at the sprinkler system demand flow from Step 1 (not the total demand from Step 2 since the water going to the sprinkler system is the only water that will go through the pump). This will be the residual pressure at the water supply (at the total demand flow from Step 2) minus the friction loss of the sprinkler demand flow going to the pump (from Step 1) minus (or plus) the elevation change between the water supply and the pump. Note that this calculation needs to be done with the reasonable worse-case conditions of the water supply.

5. Select a fire pump so that the net pressure produced by the fire pump at the sprinkler flow demand plus the suction pressure from the water supply at the total demand flow equals or exceeds the pressure demand at the pump discharge flange. Note that the pump is permitted to be used at flows up to 150% of rated flow when making this determination.

6. Calculate the suction pressure at the maximum flow for the pump (usually 150% of rated flow) and make sure that it is a positive number. Note that this needs to be done with the reasonable worse-case conditions of the water supply.

7. Calculate the maximum pressure produced by the pump (at churn) and make sure it does not overpressurize the system. This is done by taking the static pressure at the water supply plus the churn (net) pressure of the pump and subtracting (or adding) the elevation change between the water supply and the pump. Note that this needs to be done with the reasonable high static pressure from the water supply.

The example below illustrates this procedure for the same ESFR sprinkler system as Example 1, but with no hose stations inside the building and fire hydrants connected to the same municipal water supply. The water supply, suction pipe and location of the fire pump will be the same as in Example 1.

<u>Example #2</u>

The sprinklers will have a flow demand of 1350 gpm and the inside hose stream demand is 0 gpm (no hose connections inside), so the outside hose stream demand will be 250 gpm. Since the hydrants are on the municipal supply and are not supplied by the pump, the 250 gpm hose stream demand does not need to be included in sizing the pump, but needs to be taken into account when dealing with the water supply. The following information will be used in dealing with this system, pump and water supply:

- The flow demand for the sprinkler system (which is all that is being supplied by the pump) is 1350 gpm
- The total flow demand that the water supply needs to meet is 1600 gpm (1350 + 250 = 1600)
- The pressure demand at the pump suction flange has been calculated as 120 psi
- The water supply has a residual pressure of 37 psi at 1875 gpm

The steps for sizing the pump and water supply are completed as follows:

1. Done. The sprinkler system demand is 1350 gpm.

2. The total water supply demand is 1600 gpm (1350 + 250 = 1600).

3. The water supply can provide 1600 gpm at 41 psi.

4. The friction loss of 1350 gpm going through the suction pipe would be 8.1 psi (from Hazen-Williams formula). The water will begin at the municipal water supply at 41 psi (because you have to account for the fire department using the 250 gpm at the same time as the pump is taking 1350 gpm) and lose 8.1 psi to friction loss and another 6.5 psi to elevation loss, so it will arrive at the pump at 26.4 psi (41 – 8.1 – 6.5 = 26.4) suction pressure.

5. Potential pumps might include those rated at 1000 gpm, 1250 gpm or 1500 gpm. For the sake of this example, consider a 1250 gpm pump rated at 100 psi (as shown in Figure 3) with the following performance:

    a. 112 psi at churn (no flow)

    b. 100 psi at 1250 gpm

    c. 98 psi at 1350 gpm.

    d. 70 psi at 1875 gpm (150% of rated flow)

6. At a flow of 1875 gpm, the municipal water supply starts at 37 psi. The friction loss of 1875 gpm flowing through the suction pipe is 15 psi (using the Hazen-Williams formula). The elevation loss between the water supply and the pump is 6.5 psi. So the suction pressure at maximum flow will be 15.5 psi (37 – 15 – 6.5 = 15.5), which is acceptable since it is a positive number.

7. The maximum pressure produced by the pump will be 175.5 psi (112 + 70 – 6.5 = 175.5). Note that this will require slightly higher pressure ratings for the components at the elevation of the pump, but any part of the system 2 ft or more higher than the pump will only see pressures less than 175 psi. it might even be worth the effort to raise the elevation of the pump 2 ft to avoid having to purchase higher pressure rated pipe and fittings for the discharge pipe.

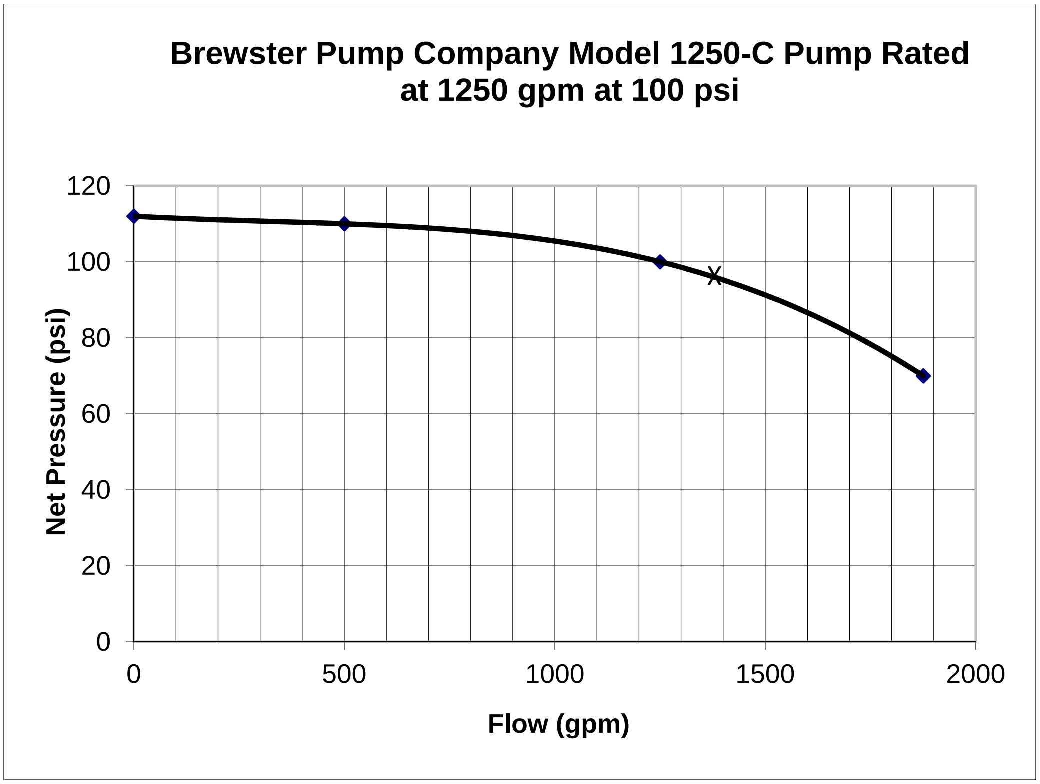


Figure 3 – 1250 gpm Pump for Example 2

The pump and the water supply discussed above will work with the fire protection system described in Example 2. The net pressure of 98 psi, when added to the suction pressure of 26.4 psi from Step 4, yields a discharge pressure of 124.4 psi, which exceeds the 120 psi required for the sprinkler system.

A comparison of the results from Example 1 and Example 2 is important. The only difference between the two examples is the location of the hose connections. Without hose connections inside the building, and without having the pump supply the fire hydrants, the size of the pump could be reduced from a 1500 gpm pump rated at 105 psi to a 1250 gpm pump rated at 100 psi. In addition, higher pressure rating equipment would not need to be used for the smaller pump situation. In either case, the total water supply needed to be capable of providing the 1600 gpm demand for the fire protection system as well as the maximum flow of the fire pump (150% of rated flow).

Upcoming NFSA "Technical Tuesday" Seminar – August 7

Topic: Protecting Multiple Buildings
Instructors: Ken Isman
Date: Tuesday, August 7, 2012- 10:30 am EST

This seminar will focus on answering two questions that are frequently asked through our "Expert of the Day" program. The first question is, "Can you protect multiple buildings with a single water supply (including a single tank and pump)?" The second question is, "Can you protect multiple buildings with a single sprinkler system?" The answers to both of the questions will depend on a number of variables, which will be explored in depth during the program.

To register or for more information, click HERE or contact Michael Repko at (845) 878-4207 or e-mail to seminars@nfsa.org.

Layout Technician Training Course (2-week course)

Fishkill, NY – October 8-19, 2012

For more information, contact Nicole Sprague using Sprague@nfsa.org or by calling 845-878-4200 ext. 149 or click HERE.

Upcoming In-Class Training Seminars

The NFSA training department also offers in-class training on a variety of subjects at locations across the country, and in recognition of the current recession has adopted a new reduced fee structure. Here are some upcoming seminars:

Aug 8	Indianapolis, IN	Inspection, Testing & Maintenance for the AHJ
Aug 15	Mashantucket, CT	Inspection, Testing & Maintenance
Aug 21-23	Phoenix, AZ	3 Day Inspection & Testing for the Fire Sprinkler Industry
Aug 28	Colorado Sprgs, CO	Sprinkler System Installation Requirements
Aug 29	Colorado Sprgs, CO	Fire Service Mains & Their Appurtenances
Aug 30	Colorado Sprgs, CO	Inspection, Testing & Maintenance

These seminars qualify for continuing education as required by NICET, and meet mandatory Continuing Education Requirements for Businesses and Authorities Having Jurisdiction.

To register for these in-class seminars, click HERE. Or contact Michael Repko at (845) 878-4207 or e-mail to seminars@nfsa.org for more information.

About the National Fire Sprinkler Association

Established in 1905, the National Fire Sprinkler Association (NFSA) is the voice of the fire sprinkler industry. NFSA leads the drive to get life-saving and property protecting fire sprinklers into all buildings; provides support and resources for its members – fire sprinkler contractors, manufacturers and suppliers; and educates authorities having jurisdiction on fire protection issues. Headquartered in Patterson, N.Y., NFSA has regional operations offices throughout the country. www.nfsa.org.