NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

TechNotes

Editor - Roland Asp, CET #482 02/22/2022

This edition of Technotes was written by Jeff Dunkel, P.E., Fire Protection Engineer at the National Fire Sprinkler Association.

Once it has been determined that a fire pump is needed to support a fire sprinkler or standpipe system, it can often be challenging to “thread the needle” to properly size the fire pump without exceeding the pressure limitations of the system components and doing so in a cost-effective manner. This edition of TechNotes is intended to assist a designer with little to no fire pump design experience learn the basics to sizing a fire pump. To start this process, we will begin by defining some basic parameters of fire pump performance criteria. This review will focus primarily on centrifugal fire pumps, however much of these requirements will apply to other types of fire pumps as well. All references to NFPA 20 will be for the 2022 edition.

Rated Fire Pump Capacity

The term fire pump capacity refers to the rated flow of the fire pump or the Gallons Per Minute (GPM) at which the fire pump is rated for. NFPA 20 dictates specific pump flow ratings ranging from 25 gpm to 5,000 gpm listed in Table 4.10.2, pumps larger than 5,000 gpm are allowed however they must be reviewed and approved by the Authority Having Jurisdiction or a Listing Laboratory. The rated capacity is primarily used as reference point, a fire pumps rated capacity is not the only single flow that pump is permitted to operate at, in fact a fire pump can support flows up to 150 percent of its rated capacity. For example, a fire pump rated for 500 gpm can support system flows up to 750 gpm and a fire pump rated for 1,000 gpm can support system flows up to 1,500 gpm. It is best practice however to select a pump so that the system demand falls between 90 percent and 140 percent of the rated capacity.

Rated Fire Pump Pressure

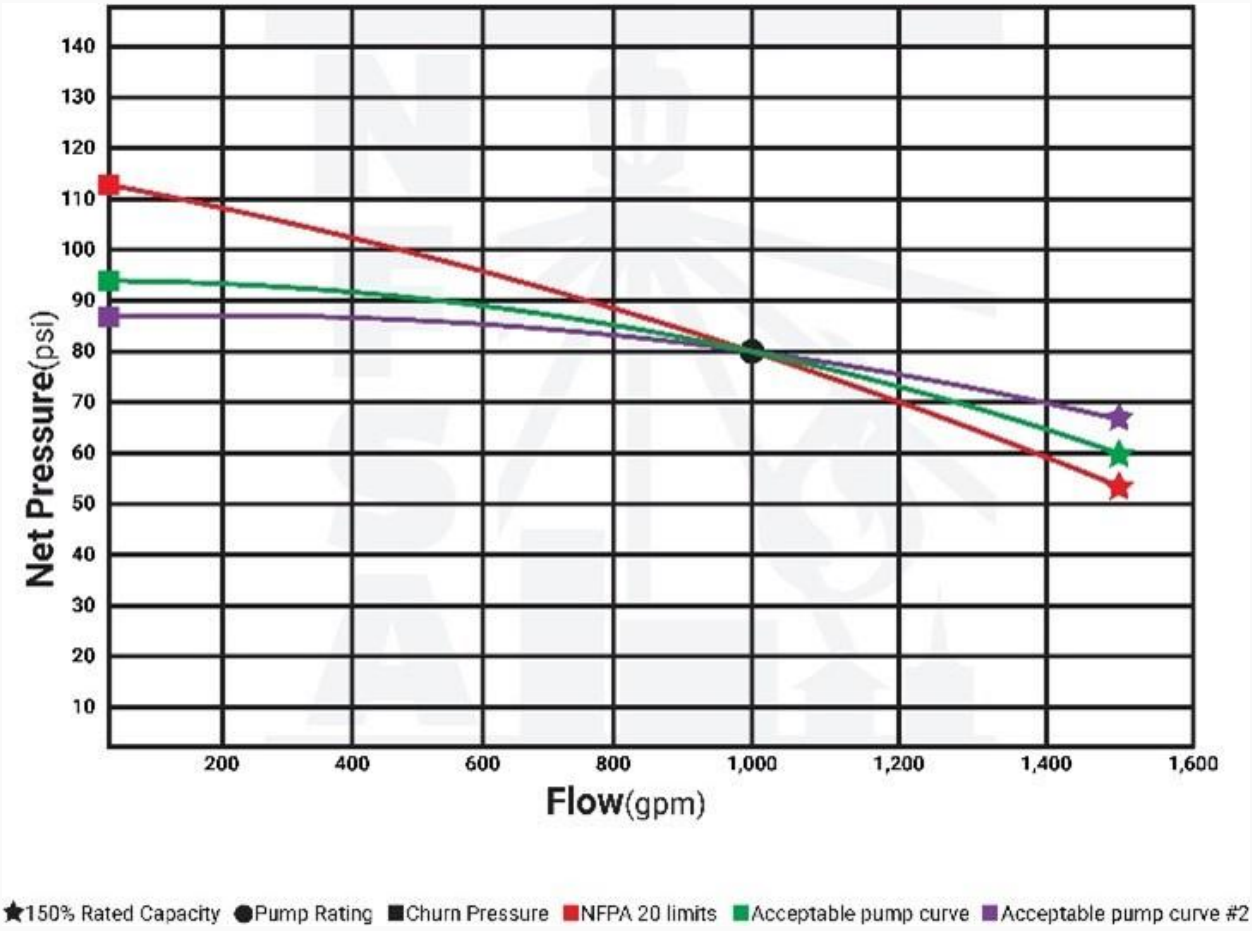
One often misunderstood aspect of pumps is that fire pumps do not create flow, if the water supply does not have the capacity to supply the required flow a fire pump will provide no value. A fire pump can only increase the pressure of the water supply. The rated pressure as defined by NFPA 20 as the net pressure (differential pressure) at rated flow and rated speed as marked on the manufacturer nameplate. Each fire pump will have a pressure at a rated flow, like the rated flow the rated pressure is also used a reference point. The pressure of a fire pump is directly related to the flow of the fire pump, as flow increases the pressure decreases, and as flow decreases the pressure increases. While the pump pressure is a function of flow NFPA 20 does dictate some limitations on the pressure output.

Maximum Churn Pressure

The fire pump pressure at no flow, often referred to shutoff or churn, cannot exceed 140 percent of the rated fire pump pressure. For example, a fire pump rated for 130 psi at 500 gpm cannot exceed 182 psi when no water is flowing, this is the maximum pressure the fire pump is allowed to put out. While the limit for all pumps is 140 percent of the rated pressure at churn the limit for centrifugal fire pump was 120 percent at one point in history, for this reason you will find that most centrifugal fire pumps available today still will not exceed 120 percent of the rated pressure at churn.

Minimum Fire Pump Pressure

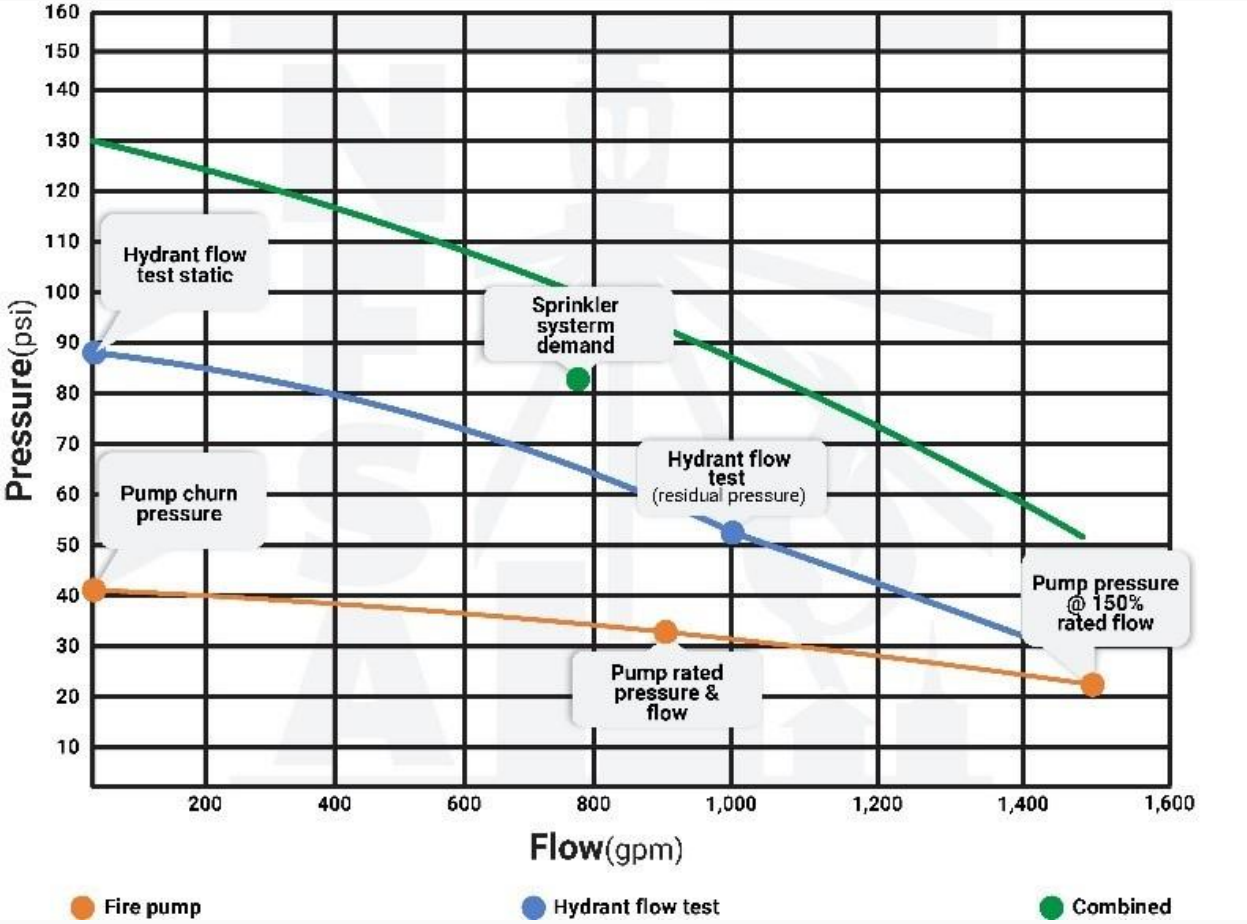
In addition to limiting the churn pressure, NFPA 20 dictates the minimum pressure permitted from a fire pump. Per NFPA 20 Section 6.2.1 pumps shall furnish not less than 150 percent of the rated capacity at not less than 65 percent of the total rated head. This means at 150 percent of the fire pumps rated flow the pressure must be at least 65 percent of the rated pressure. For example, a pump rated for 130 psi at 500 gpm must be capable of producing a minimum of 84.5 psi at 750 gpm. The pressure limitations are illustrated in the figure in this article.



Suction Pressure, Differential Pressure and Discharge Pressure

As stated above a fire pump cannot create flow, the water supply must be able to supply the required flow at the minimum suction pressure dictated by the pump manufacturer. A fire pump can only increase the pressure of the water supply, the pressure provided by the water supply is the suction pressure, the pressure provided by the fire pump is the differential pressure. The discharge pressure is the total of the suction pressure and the differential pressure, for example if the water supply has a pressure of 40 psi at 1,000 gpm at the suction flange of the fire pump and the fire pump has a rated

pressure of 60 psi at 1,000 gpm the discharge pressure is 100 psi at 1,000 gpm. Adding the pressure in this manner is done at all flow points along the curve as shown in the illustration.



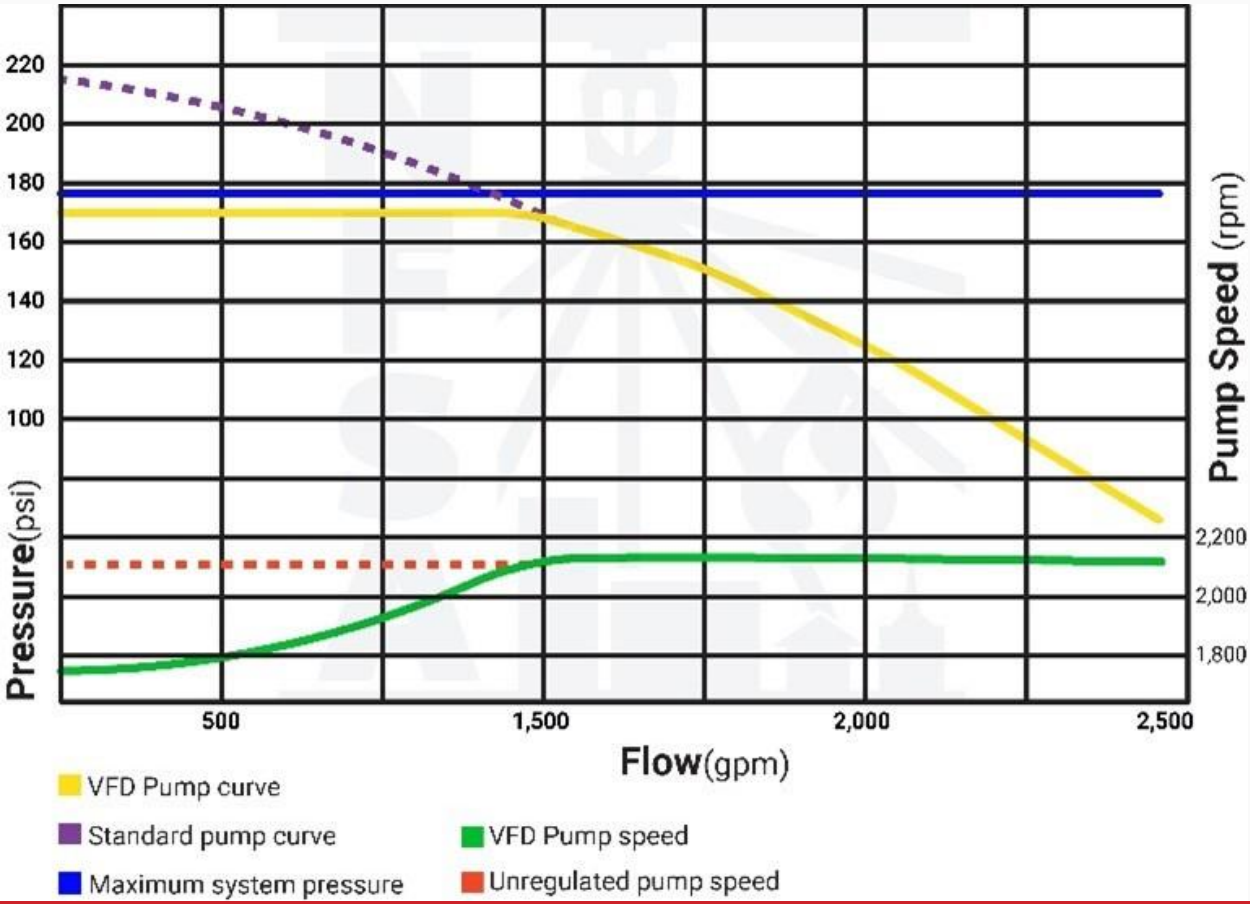
Fire Pump Component Sizing

Up to this point we have focused on sizing of the fire pump itself, however minimum sizes for the components are provided in table 4.28 of NFPA 20. This table provides minimum sizes for Pump suction, discharge, relief valves, flow meters and test headers based on the rated capacity of the fire pump. The size of the fire pump suction is based on a flow velocity of 15 feet per second when the fire pump is flowing at 150 percent of the rated capacity. While the size of the hose header supply is provided in this table, if this supply line is longer than 15 feet it must be one pipe size larger than the diameter referenced in the table, or this line can be hydraulically calculated. The 2022 edition of NFPA 20 added a requirement that the hose header supply line shall be increased if this line contains more than 4 fittings that change the direction of flow.

Threading the Needle

Choosing a fire pump that can adequately boost the supply pressure sufficiently to meet the needs of the fire suppression system demand is only half the battle. There will always be a limit to the pressure that fire suppression system can sustain. While high pressure fittings are available, 175 psi is the most common maximum pressure rating for components on a fire suppression system, at times a maximum pressure of 175 psi cannot be avoided. For example, ESFR sprinklers are only available with a maximum pressure rating of 175 psi. The fire pump must not only sufficiently boost the pressure to meet the demand, the churn pressure plus the static pressure of the water supply must not exceed the maximum pressure rating of the system components. Depending on the situation this can be challenging, some supplies are inadequate due to a steep curve, meaning the static pressure is high and the residual pressure is low. With a combination of a steep supply curve and a high demand from the suppression system it may not always be possible to use a standard, constant speed fire pump.

When a constant speed fire pump is not an option it may be possible to use a variable speed fire pump. A variable speed fire pump adjusts the pump speed to reduce the pressures at lower flows, providing a “flatter” curve and allow the use of a larger pump without the high static pressure. A variable speed fire pump does have down sides, one of which is the size. For electric variable speed fire pumps the controller must be equipped with a variable frequency drive (VFD), which can be very larger. Along with a larger footprint variable speed fire pumps come with a considerably larger price tag. A diesel variable speed pump has less of an impact on both size and price. A diesel pump adjusts the speed by using a pressure limiting device (PLD), which does impact cost, but not to the same degree as a VFD.



Conclusion

A poor water supply can be challenging, and if the supply cannot provide the required flow at the minimum required suction pressure, which for some jurisdictions cannot be lower than 20 psi, a pump alone is not sufficient, a suction tank would then be required. If the flow is available but the static pressures are still and issue, variable speed pump or a break tank could possibly be the solution. Whichever solution is chosen it is important to understand the fire pump system must be capable of supporting the system demand without exceeding the system pressure.

Learning and Development

Layout Technician Training

The purpose of the layout technician course is to take a person with basic knowledge of math, physical science and drafting skills and teach them to be productive basic sprinkler layout and detailing technicians. All of the work elements necessary for NICET Level II Certification will be covered by the course including sprinkler selection, sprinkler spacing and location, obstructions to sprinklers, water supplies (public mains, tanks and pumps), hydraulic calculation of sprinkler systems, and standpipe system layout and calculation.

Layout Technician Training
Virtual Training Class

March 22nd - April 14th, 2022
Registration ends March 4th, 2022

Register Here

Layout Technician Blended Learning
Virtual Practicum

Last chance to complete the blended learning LTTC!
(Seriously)

April 6th - 14th, 2022
Registration ends March 18th, 2022

Register Here

National Fire Sprinkler Association
514 Progress Dr, Ste A,
Linthicum Heights, MD 21090
1-800-683-NFSA (6372)

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry