SCHIRMER ENGINEERING
707 Lake Cook Road, Ste. 200
Deerfield, IL 60015
Phone (847) 272-8340 Fax (847) 272-2639

Fire Protection ■ Code Consulting ■ Risk Control ■ Security Consulting

APPLYING VARIABLE SPEED PRESSURE LIMITING CONTROL DRIVER FIRE PUMPS

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APPLYING PRESSURE LIMITING PUMPS TO FIRE PROTECTION APPLICATIONS

I. ABSTRACT

Variable Speed pressure limiting control driven fire pumps are now permitted by the 2003 edition of NFPA 20. This article discusses the characteristics of these pumps, and the practical application of these pumps in high rise, and ESFR applications.

II. INTRODUCTION

Variable Speed pressure limiting control drivers were added to the 2003 edition of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.* This article discusses the practical application in high rise and ESFR systems.

The following terms will be used in this article.

Net pump pressure:	Pressure developed by the fire pump (discharge pressure minus suction pressure.
Net churn pressure	Pressure developed by the fire pump when operating at no flow.
Net operating pressure or Net rated pressure:	The net pump pressure developed by the fire pump when operating at rated flow.
Operating pressure:	For purposes of this article, operating pressure refers to pressures developed when the pump is operating at rated speed and rated flow.
Churn pressure or Shut off pressure:	The pump discharge pressure when operating at no flow.
Pump suction pressure:	The pressure measured at the fire pump suction flange.
Pump discharge pressure:	The pressure measured at the fire pump discharge flange (net pump pressure plus pump suction pressure)
Pressure relief valve	A pilot operated or spring operated valve, in the flow stream, that limits the system pressure by discharging water to atmosphere or to the pump suction, thereby preventing the fire pump from operating under churn or low flow conditions.
Pressure control valve	A pilot operated valve, in the flow stream, that limits the system pressure downstream of the valve.
Variable speed pressure limiting control (VSPLC) drivers:	Pump driver or driver and controller combination which limits the pump discharge pressure by reducing the pump speed.

System working pressure: The maximum pressure a sprinkler system can operate, limited by the component in the system with the lowest maximum working pressure.

III. HISTORY

Several editions of NFPA 20 have been concerned about preventing excessive pump discharge pressures, usually associated with churn (no flow) conditions, from over pressurizing system components downstream of the fire pump.

Historically fire pumps have been designed and listed for constant speed operation. It is characteristic of these pumps for the discharge pressure at churn to exceed the discharge pressure when operating at rated flow for three reasons. First, NFPA 20 allows the net churn pressure to exceed the net operating pressure by up to 40%. Second, the suction pressure normally decreases as the flow through the pump increases. The drop in suction pressure is dependent on the water supply characteristics but may be substantial. Third, there is typically a variance (sometimes extreme) in the pump suction pressure during a 24 hour period with additional variances for specific days of the week and seasons of the year.

One design approach, used prior to the 1999 edition of NFPA 20, was to select a fire pump based on the operating pressure, and install a pressure relief valve to discharge water to atmosphere so that the pump is always operating with flow through the pump, thereby preventing the higher pressures which occur under churn conditions and therefore prevent system over-pressure. This practice has several drawbacks. First, the operation of the pressure relief valve is not instantaneous, and the system downstream of the fire pump may experience excessive pressure before the relief valve can operate. Second, pressure relief valve may fail to operate properly. If the pressure relief valve fails in the open position, it may prevent adequate water from reaching the hazard. If the pressure relief valve fails to open, the system may be subjected to a substantial shock. Conventional wisdom holds that pressure relief and pressure control valve are reliable if they are maintained. However, the author is aware of the failure of one pressure control valve and two pressure relief valves. In one installation, a pressure control valve failed open during annual testing, however, the system was able to contain the excess pressure. In another installation, a pressure relief valve failed in the open position during a fire, resulting in a substantial fire loss. In yet another installation, a pressure relief valve failed to open and resulted in two 6-inch screwed tees splitting with substantial water damage. While this experience is limited and does not provide adequate insight into the actual reliability of these devices, it does indicate caution should be used in applying these devices.

In 1999 wording was added to NFPA 20 to limit the discharge pressure so that the system working pressure would not be exceeded. The wording was modified in 2003 to specifically prohibit using a pressure relief valve to meet this requirement, i.e. pressure relief valves are not permitted to control net churn pressure. Pressure relief valves are still required for some abnormal conditions such as diesel pump overspeed and with variable speed drivers. Pressure control valves are not specifically prohibited from being used to control the pressure delivered to the system. Also specific wording was added to allow variable speed pressure limiting controllers to limit the pump discharge pressure.

IV. VARIABLE SPEED PRESSURE LIMITING CONTROL PUMP CHARACTERISTICS

With constant speed (traditional) fire pumps, the net discharge pressure decreases as the flow rate increases. With variable speed pressure limiting control fire pumps, the discharge pressure is monitored and the pump speed is modulated down to limit the pump discharge pressure to a preset maximum. Once the pump reaches its rated speed, the pressure follows a traditional fire pump curve.

A diesel engine is inherently a variable speed driver where the speed is controlled with a throttle. The speed of an electric motor is controlled by changing the characteristics of the electricity sent to the motor.. While the exact mechanism for controlling the pump's speed is beyond the scope of this article is should be noted that the controller that changes the characteristics is relatively costly. The cost of a variable speed diesel engine is less than a variable speed electric motor.

The pump affinity laws can be used to determine the effect pump speed has on the flow and pump discharge pressure.

The change in flow is determined by the following formula:

$$Q_{R2} = Q_{R1}*(R_2/R_1)$$

The change in pressure is determined by the following formula:

$$P_{R2} = P_{R1}*(R_2/R_1)^2$$

Where

Q_{R1} = flow rate when the pump speed is R_1
Q_{R2} = flow rate when the pump speed is R_2
P_{R1} = net pressure when the pump speed is R_1
P_{R2} = net pressure when rate when the pump speed is R_2
R_1 = pump rated speed
R_2 = pump speed when reduced (by VSPLC)

Figure 1 graphically shows the pump suction pressure, the net pump pressure, the pump discharge pressure, and the pump speed for a traditional constant speed fire pump with a rating of 1000gpm @ 150psi @1760 rpm when the suction pressure is 55 psi at churn and 30 psi at 1500gpm . Figure 2 shows the same information for the same fire pump with a variable speed pressure limiting driver. For this example, the VSPLC has a 170 psi set point with a maximum control pressure of 175 psi.

With a variable speed pressure limiting driver, it is possible to achieve the design pump discharge pressure at any flow within the flow rating of the pump, without exceeding the system working pressure. This is demonstrated by comparing figure 4 to figure 2. In figures 3 and 4, the pressure rating of the fire pump was increased from to 170 psi (versus 150 psi in figures 1 and 2) and the discharge pressure at 1250gpm increased from 166psi to 175psi.

FIGURE 1
CONSTANT SPEED 1000GPM @ 150PSI @ 1760RPM FIRE PUMP

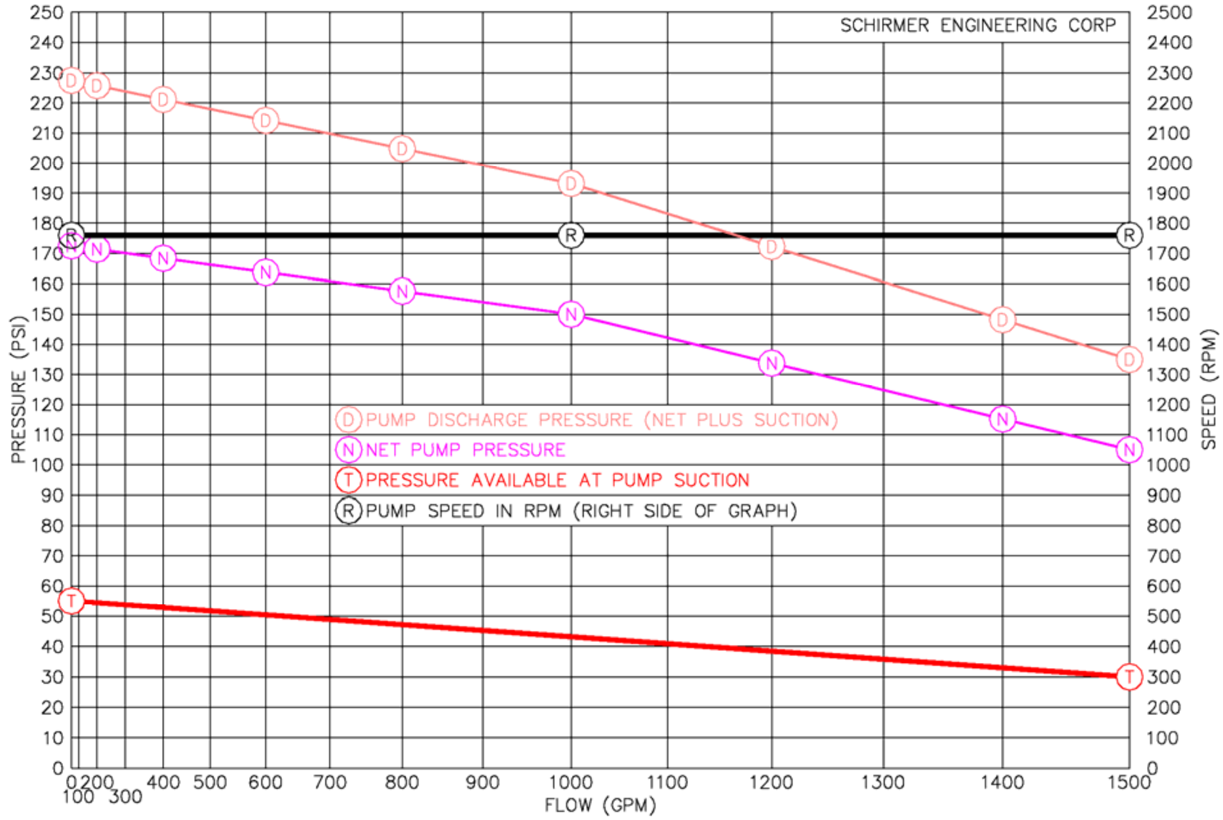


FIGURE 2
VARIABLE SPEED 1000GPM @ 170PSI @ 1760RPM FIRE PUMP

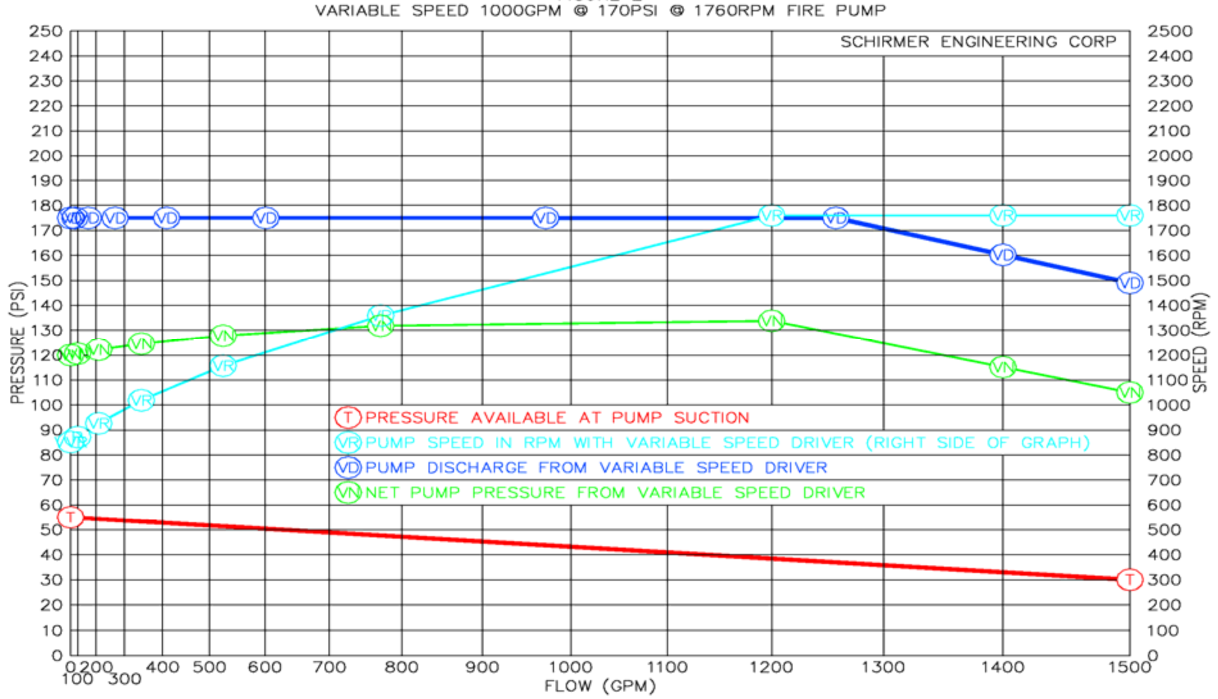


FIGURE 3
CONSTANT SPEED 1000GPM @ 170PSI @ 1760RPM FIRE PUMP

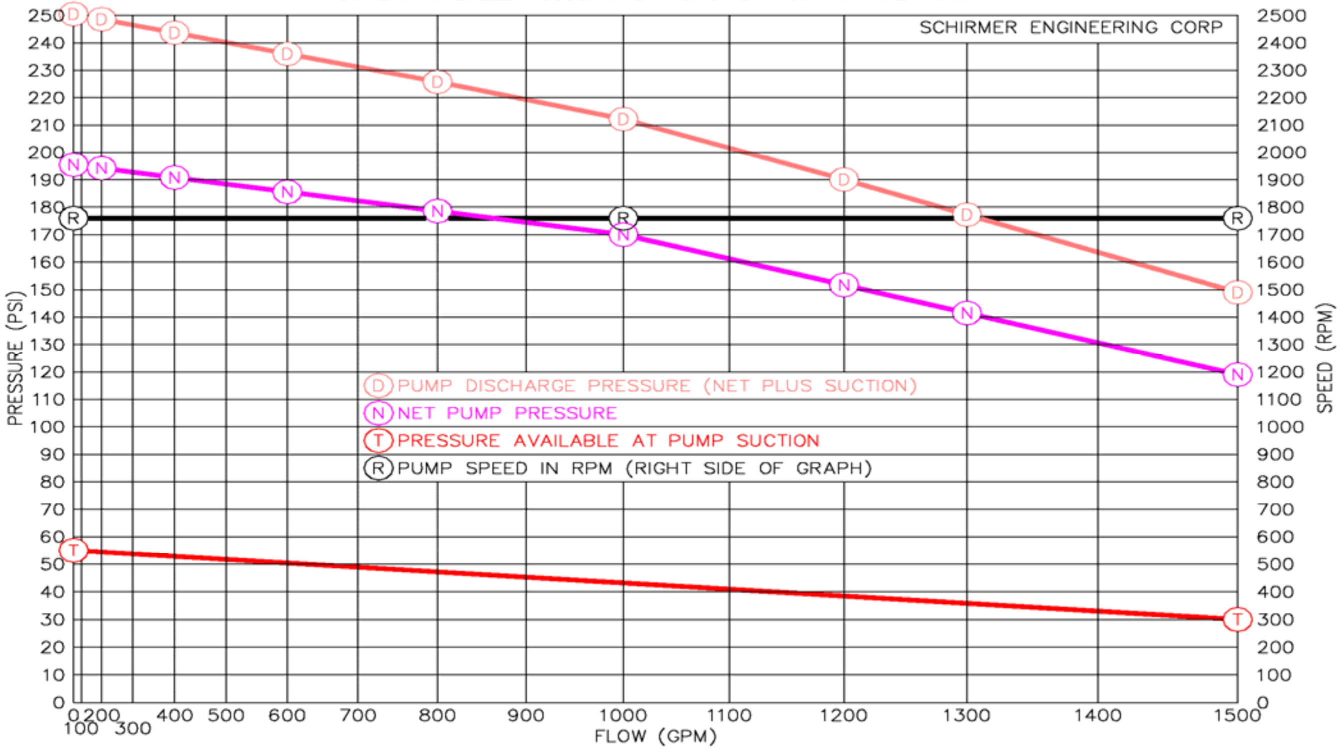
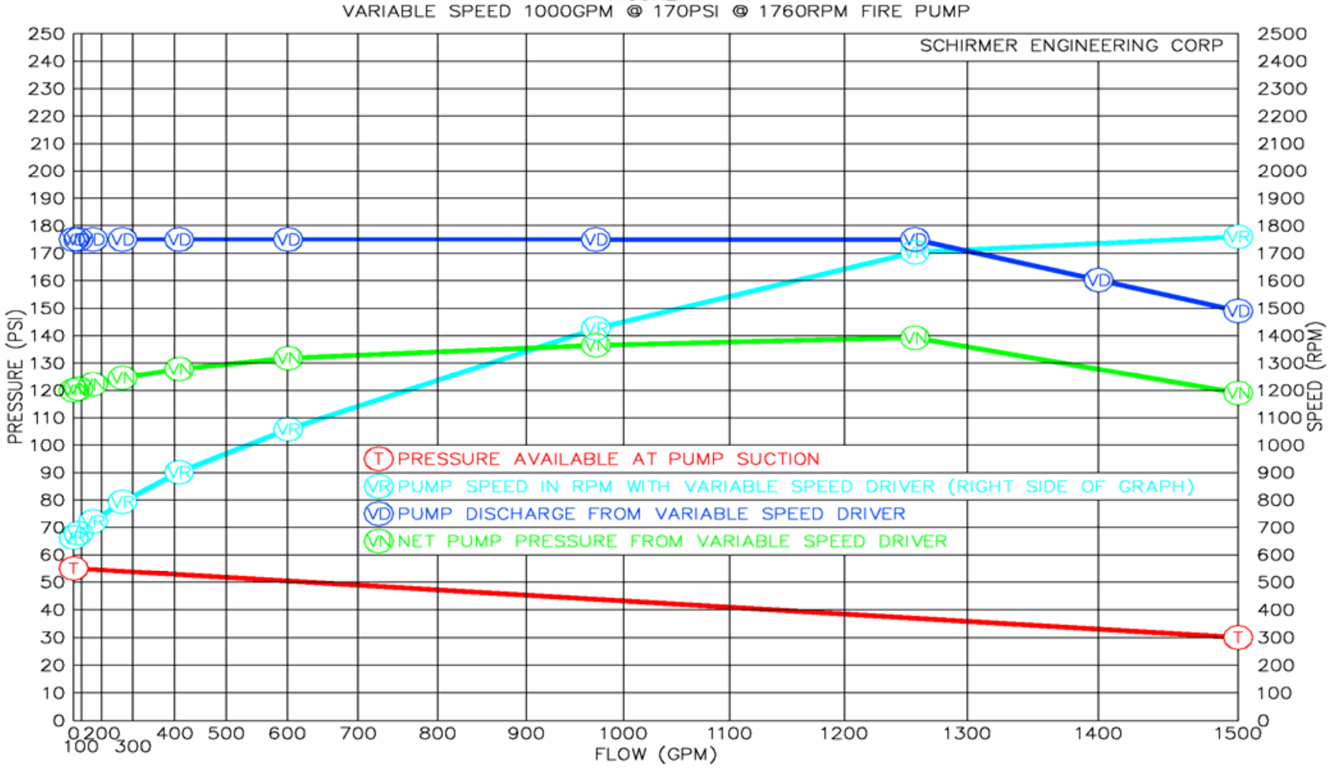


FIGURE 4
VARIABLE SPEED 1000GPM @ 170PSI @ 1760RPM FIRE PUMP



V. DESIGN CONSIDERATIONS

If the variable speed pressure limiting control fails to operate properly, NFPA 20 requires the fire pump to return to rated speed and therefore will operate as a traditional constant speed fire pump. This could cause the pump discharge pressure to exceed the system working pressure. To protect against this possibility, NFPA 20 requires a pressure relief valve to be installed on all variable speed pressure limiting control fire pumps. From the discharge flange of the fire pump to the indicating control valve, system components must be rated for the highest potential pressure.

Failure of the variable speed pressure limiting control is anticipated to be an unlikely event and experience may eventually allow the requirement for a pressure relief valve to be removed from NFPA 20.

VI. DESIGN FOR HIGH RISE

NFPA 14 currently requires the water supply to be capable of providing 500 gpm for the first standpipe and 250 gpm for each additional standpipe up to a maximum of 1000 gpm for a fully sprinklered, light hazard occupancy building. 500 gpm must be available at the topmost two outlets (250 gpm each) at a residual pressure of 100 psi, except NFPA 14 does allow the authority having jurisdiction to lower the pressure requirement to 65 psi. Some municipalities, such as the city of Chicago, require 500 gpm @ 65 psi at the topmost outlet.

NFPA 14 limits the maximum pressure on any part of a standpipe system to 350 psi.

NFPA 13 and NFPA 14 allow the use of pressure control valves to reduce pressure to a sprinkler or standpipe system. However, currently, the use of "master" pressure reducing valves (a single pressure reducing that controls the water supply to multiple fire protection systems) is controversial and introduces reliability issues that need further investigation. In addition, some municipalities, such as Chicago, IL prohibit the use of any pressure reducing devices in sprinkler and standpipe systems (except for individual fire hose valves). The following table 1 was prepared to show the effect of utilizing variable speed pressure limiting controlled pumps. The table indicates the number of floors that can be served without the use of pressure control valves: NOTE: The hose valves must be of a pressure reducing type whenever the pressure at the valve exceeds 175 psi.

- Systems requiring 500gpm @ 100psi at the topmost outlet.
- Systems requiring 500gpm @ 65psi at the topmost outlet
- Using 175 psi rated system components
- Using 250 psi rated system components
- Various floor to floor dimensions.
- Fire pumps that churn @ 110% of rated pressure
- Fire pumps that churn @ 120% of rated pressure
- Fire pumps that churn @ 130% of rated pressure

The following assumptions were used to develop these tables 1 and 2:

- The standpipes demand is 1000gpm.
- The suction pressure at rated flow is 15 psi less than the suction pressure at churn. The water supply at the pump suction is 50 psi static, 35 psi residual, flowing 1000 gpm.
- The friction loss from the fire pump to the standpipe riser is 2 psi at 1000gpm. This corresponds to flowing 1000gpm through 250 feet of 8-inch thinwall pipe. The friction loss in the standpipe riser is 0.008psi/ft which corresponds to flowing 500gpm through 6-inch pipe.

Table 1
THE EFFECT OF VARIABLE SPEED PUMPS ON STANDPIPE ZONING

Static Pressure Bottom (psi)	Residual Pressure Top (psi)	Churn %	Driver Type[1]	Rated Pump Pressure (psi)	Residual Pressure Bottom (psi)[2]	Static Pressure Top (psi)	Height of Zone (feet)	No of Floors @ Typical Flr-Flr - (feet)					
								8	9	10	11	12	13
250	100	110%	C	177	210	140	250	31	27	25	22	20	19
			V	215	248	102	336	41	37	33	30	27	25
		120%	C	158	191	159	207	25	23	20	18	17	15
			V	215	248	102	336	41	37	33	30	27	25
		130%	C	142	175	175	171	21	18	17	15	14	13
			V	215	248	102	336	41	37	33	30	27	25
250	65	110%	C	177	210	105	330	41	36	32	29	27	25
			V	215	248	67	415	51	46	41	37	34	31
		120%	C	158	191	124	287	35	31	28	26	23	22
			V	215	248	67	415	51	46	41	37	34	31
		130%	C	142	175	140	250	31	27	25	22	20	19
			V	215	248	67	415	51	46	41	37	34	31
175	100	110%	C	109	142	133	96	11	10	9	8	7	7
			V	140	173	102	166	20	18	16	15	13	12
		120%	C	96	129	146	65	8	7	6	5	5	5
			V	140	173	102	166	20	18	16	15	13	12
		130%	C	85	118	157	40	4	4	3	3	3	3
			V	140	173	102	166	20	18	16	15	13	12
175	65	110%	C	109	142	98	175	21	19	17	15	14	13
			V	140	173	67	245	30	27	24	22	20	18
		120%	C	96	129	111	145	18	16	14	13	12	11
			V	140	173	67	245	30	27	24	22	20	18
		130%	C	85	118	122	119	14	13	11	10	9	9
			V	140	173	67	245	30	27	24	22	20	18

[1] C indicates a constant speed fire pump
V indicates a variable speed pressure limiting control fire pump
[2] Residual pressure at bottom of riser at a flow of 1000gpm

The above table shows the number of floors that can be on a standpipe zone without exceeding the pressure rating of the systems components, and without using pressure control valves. As a minimum, sprinkler system and standpipe components are listed for 175 psi operating pressure. Sprinkler system and standpipe components are available that are listed for 250 psi or 300 psi. It should be noted that not all sprinklers are available with a 250 psi or 300 psi listing, and FM does not list sprinklers for 250 psi. NFPA 14 limits the maximum pressure on a standpipe system to 350 psi. The available sprinklers should be reviewed before deciding to design a standpipe / sprinkler system to a maximum pressure above 175 psi.

Using variable speed pumps with a fluctuating water supply is described in the following section, however, it should be noted that a fluctuating water supply would reduce the number of floors that can served by a constant speed pump below what is indicated in Table 1, while, with proper design, a fluctuating water supply would not reduce the number of floors served by a variable speed pump.

For constant speed pumps, the churn pressure has a significant impact on the number of floors that can be on a zone, i.e. a pump that churns at 110% of rated pressure can serve more floors than a pump that churns at 120%. With a variable speed pressure limiting driver, the pump speed (and pressure) can be reduced so that the system is not subjected to the constant speed churn pressure, and the higher churn rated pressures do not affect the number of floors that can be on a zone.

The cost impact of a variable speed pump may be significant. Eliminating a standpipe/sprinkler zone in a high riser could reduce the cost of the fire protection system by $70,000-$100,000 by eliminating a fire pump and express risers. As an example a 20 to 25 story building with a typical floor to floor dimension of 12-feet requires a two zone standpipe / sprinkler system with a constant speed fire pump, but only one zone with a variable speed pressure limiting control fire pump.

The following table 2 shows calculated static and residual pressures on each floor of a building having a two zone standpipe/sprinkler system, with the zone 2 fire pump arranged in series with the zone 1 fire pump and a typical 12-ft. floor to floor height. Table 2 is based on a maximum standpipe pressure of 250 psi and a maximum express riser pressure of 350 psi. The flow and friction loss assumptions are the same as used for table 1. The pumps used for the calculations are shown at the bottom of table 2.

Table 2
Typical Static and Residual Pressures on a Two Zone Standpipe System

Floor	Elevation	Standpipe Zone 1				Standpipe Zone 2			
		Constant Speed		Variable Speed		Constant Speed		Variable Speed	
		Static Press (psi)	Residual Press (psi)	Static Press (psi)	Residual Press (psi)	Static Press (psi)	Residual Press (psi)	Static Press (psi)	Residual Press (psi)
47	552							109.0	103.6
46	540							114.2	108.9
45	528							119.4	114.2
44	516							124.6	119.5
43	504							129.8	124.8
42	492							135.0	130.1
41	480							140.2	135.4
40	468							145.4	140.7
39	456					147.6	101.0	150.6	146.0
38	444					152.8	106.3	155.8	151.3
37	432					158.0	111.6	161.0	156.6
36	420					163.2	116.9	166.2	161.9
35	408					168.4	122.2	171.4	167.2
34	396					173.6	127.5	176.6	172.5
33	384					178.8	132.8	181.8	177.8
32	372					184.0	138.0	187.0	183.1
31	360					189.2	143.3	192.2	188.4
30	348					194.4	148.6	197.4	193.7
29	336					199.6	153.9	202.6	199.0
28	324			107.8	104.2	204.8	159.2	207.8	204.2
27	312			113.0	109.5	210.0	164.5	213.0	209.5
26	300			118.2	114.8	215.2	169.8	218.2	214.8
25	288			123.4	120.1	220.4	175.1	223.4	220.1
24	276			128.6	125.3	225.6	180.4	228.6	225.4

Table 2 Typical Static and Residual Pressures on a Two Zone Standpipe System									
		Standpipe Zone 1				Standpipe Zone 2			
		Constant Speed		Variable Speed		Constant Speed		Variable Speed	
Floor	Elevation	Static Press (psi)	Residual Press (psi)	Static Press (psi)	Residual Press (psi)	Static Press (psi)	Residual Press (psi)	Static Press (psi)	Residual Press (psi)
23	264			133.8	130.6	230.8	185.7	233.8	230.7
22	252	137.0	100.9	139.0	135.9	236.0	191.0	239.0	236.0
21	240	142.2	106.2	144.2	141.2	241.2	196.3	244.2	241.3
20	228	147.4	111.5	149.4	146.5	246.4	201.6	249.4	246.6
19	216	152.6	116.8	154.6	151.8	251.6	206.9	254.6	251.9
18	204	157.8	122.1	159.8	157.1	256.8	212.2	259.8	257.2
17	192	163.0	127.4	165.0	162.4	262.0	217.5	265.0	262.5
16	180	168.2	132.7	170.2	167.7	267.2	222.8	270.2	267.8
15	168	173.4	138.0	175.4	173.0	272.4	228.0	275.4	273.0
14	156	178.6	143.3	180.6	178.3	277.6	233.3	280.6	278.3
13	144	183.8	148.6	185.8	183.6	282.8	238.6	285.8	283.6
12	132	189.0	153.9	191.0	188.9	288.0	243.9	291.0	288.9
11	120	194.2	159.2	196.2	194.2	293.2	249.2	296.2	294.2
10	108	199.4	164.5	201.4	199.5	298.4	254.5	301.4	299.5
9	96	204.6	169.8	206.6	204.8	303.6	259.8	306.6	304.8
8	84	209.9	175.1	211.9	210.1	308.9	265.1	311.9	310.1
7	72	215.1	180.4	217.1	215.4	314.1	270.4	317.1	315.4
6	60	220.3	185.7	222.3	220.7	319.3	275.7	322.3	320.7
5	48	225.5	191.0	227.5	226.0	324.5	281.0	327.5	326.0
4	36	230.7	196.3	232.7	231.3	329.7	286.3	332.7	331.3
3	24	235.9	201.5	237.9	236.5	334.9	291.6	337.9	336.6
2	12	241.1	206.8	243.1	241.8	340.1	296.8	343.1	341.8
First	0	246.3	212.1	248.3	247.1	345.3	302.1	348.3	347.1

Zone 1 Standpipe pressures
Zone 2 Standpipe pressures
Express Riser Zone 2 Standpipe pressures
Zone 1 Constant Speed Fire Pump: 1000gpm @ 180psi, churn 110%
Zone 2 Constant Speed Fire Pump: 1000gpm @ 90psi, churn 110%
Zone 1 Variable Speed Fire Pump: 1000gpm @ 215psi, churn 110-140%
Zone 2 Variable Speed Fire Pump: 1000gpm @ 100psi, churn 110-140%

The table indicates that a 40 to 47 story building with a typical floor to floor dimension of 12-feet requires a three zone standpipe / sprinkler system with a constant speed fire pump, but only two zones with a variable speed pressure limiting control fire pump.

VII. DESIGN FOR ESFR SPRINKLERS AND FLUCTUATING WATER SUPPLIES

In most cases, K-25 ESFR sprinklers can significantly lower the operating pressures for ESFR sprinkler systems. With 25 foot high storage in a 30 foot high building, a K-14 sprinkler requires a minimum pressure of 50 psi, while a K-25 sprinkler requires a minimum pressure of 15 psi. However, the list price of a K-25 ESFR sprinkler is approximately $30.00 per sprinkler higher than a K-14 ESFR sprinkler. If the contractor discount is 50%, the cost differential is approximately a $15.00 per sprinkler. This means in a 100,000 square foot building requiring 1000 ESFR sprinklers, the costs of the sprinklers could be lowered by $15,000.00 by providing an additional 35 psi of residual pressure in the water supply.

Example: A 40 feet high building with 35 feet high storage a K-14 ESFR sprinkler system must operate a minimum of 12 sprinklers at a minimum pressure of 75 psi, which equates to a minimum flow rate 121.2 gpm per sprinkler or a minimum of 1455 gpm for the sprinkler system. Adding 5% overage to the sprinkler system flow, and a 250 gpm hose stream allowance, results in a total water demand of approximately 1775 gpm.

The water supply must have sufficient pressure to supply a pressure of 75 psi at the most remote sprinkler plus 17 psi to overcome the elevation difference, plus sufficient pressure to overcome the friction loss in the system. While system friction losses can be minimized with large pipes, having 40-60 psi available for friction loss allows designing a more economical system. This means 133-153 psi should be available at the base of the riser.

The effect of pressure on the pipe size can be understood better by looking at the Hazen-Williams formula for pressure loss in pipes:

$$f = \frac{4.52*Q^{1.85}*L}{C^{1.85}\,D^{4.87}} \qquad \text{Or} \qquad D=\left(\frac{4.52*Q^{1.85}*L}{f*C^{1.85}}\right)^{(1/4.87)}$$

Where

f	=	Friction Loss in psi
Q	=	Flow through pipe in gpm
C	=	Hazen Williams Coefficient (a measure of smoothness), 120 for wet pipe sprinkler systems
D	=	Pipe diameter in inches
L	=	Equivalent pipe length in feet

From this formula it can be noted that doubling the pressure available for friction loss does not reduce the allowable pipe by half. In practice the allowable pipe size reduction becomes marginal whenever the pressure available for friction loss exceeds 50-75 psi.

Water supply characteristics vary widely. Some water systems could provide this flow rate with a pressure fluctuation of less than 5 psi, while in other water systems the pressure fluctuation might be 50 or even 100 psi at this flow rate. Seasonal variations also effect the fluctuations.

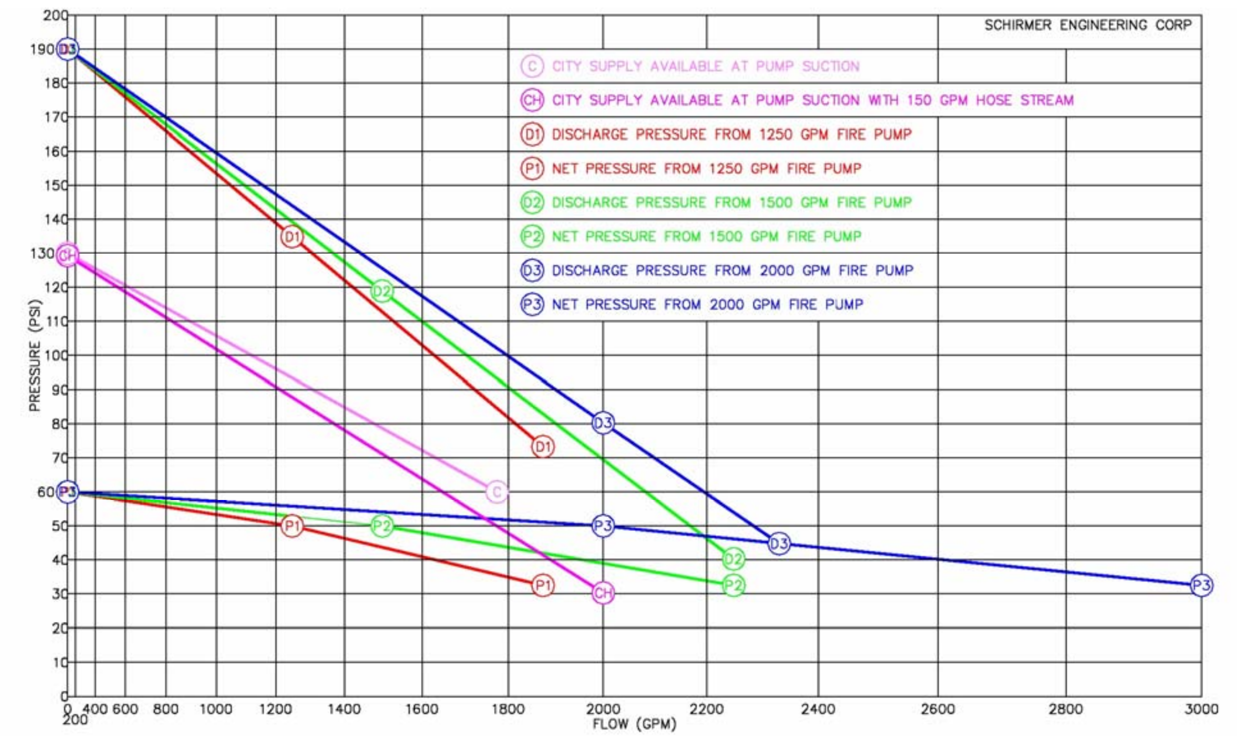
For purposes of showing the effect of a variable speed pressure limiting control fire pump on the available design pressure, we will assume the water supply at the pump suction has a static pressure of 130 psi, a residual pressure 60 psi at a flow rate of 1775 gpm. The building height is 40 feet, the sprinkler system is designed for 1525 gpm, the inside hose stream demand is 100 gpm and the outside hose stream demand is 150 gpm.

Currently, K-14 and K-25 sprinklers are listed for a maximum system pressure of 175 psi. If the sprinklers are 40 feet above the fire pump, the maximum fire pump churn pressure is 192 psi. If the fire pump churns at 120% of its net pump pressure, then the maximum net pump pressure rating that will not exceed the pressure rating of the sprinkler is 50 psi. Table 3 shows the design pressure available at the pump discharge for constant speed pumps.

Table 3
Comparison of available design pressures with Constant Speed Fire Pumps

Rated Capacity		1250	1500	2000
Constant Speed Pump	Rated Pressure	50	50	50
	Available Discharge Pressure[1]	90.2	97.5	103.2
	HP	60	60	100

[1]Discharge pressure available with a 150 gpm outside hose demand and 1625 gpm fire pump discharge
Static Pressure 130, Residual Pressure 60, Flow 1775 gpm, Building height 40 feet

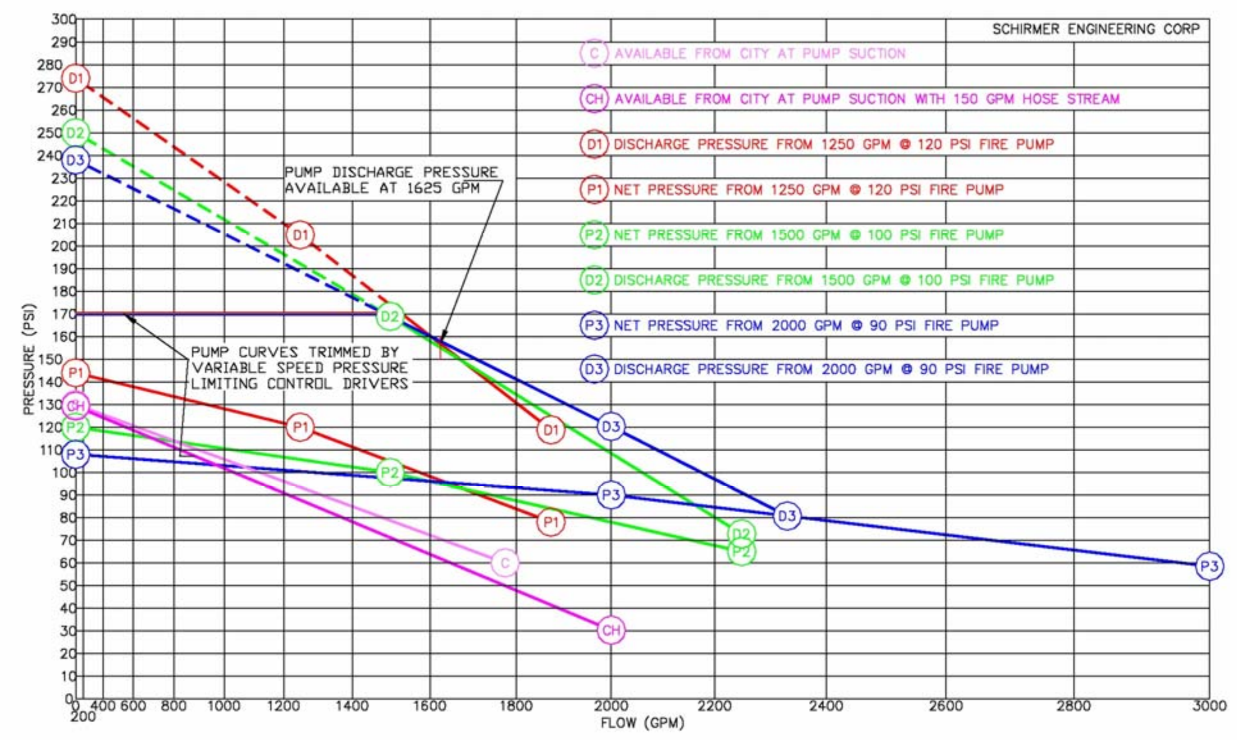


Pump Curves For Constant Speed Pumps

With a constant speed fire pump, it is frequently impractical to design beyond 110% of the rated flow because of the decline in available pressure. The above table 3 and pump curves shows a 2000 gpm @ 50 psi fire pump provides 13 psi more pressure @ 1625 gpm than a 1250 gpm @ 50 psi fire pump.

Table 4 Comparison of available design pressures with Variable Speed Fire Pumps				
Rated Capacity		1250	1500	2000
Variable Speed Pump	Rated Pressure	120	100	90
	Available Discharge Pressure[1]	146.5	145.0	145.7
	HP	150	125	150-200
[1]Discharge pressure available with a 150 gpm outside hose demand and 1625 gpm fire pump discharge Static Pressure 130, Residual Pressure 60, Flow 1775 gpm, Building height 40 feet				

However, with a variable speed pressure limiting control fire pump the rated pump pressure can be increased so that a 1250 gpm pump can deliver the same design pressure as a 2000 gpm fire pump when the design flow rate is less than 1875 gpm. This is demonstrated in Table 4 where a 1250 gpm @ 120 psi fire pump can deliver the same pressure at a flow rate of 1625 gpm as a 1500 gpm @ 100 psi, and a 2000 gpm @ 90 psi fire pump. This may reduce the power requirements and pump cost.



Pump Curves With Variable Speed Pump

VIII. CONCLUSIONS

A. A variable speed pressure limiting controlled fire pump significantly increases the number of floors that can be included in a single standpipe zone without resorting to pressure control valves. Eliminating a standpipe zone in a high rise building could reduce the cost of the standpipe / sprinkler system by $70,000-$100,000

B. Variable speed pressure limiting control fire pumps can significantly increase the pressure available for design without resorting to pressure control valves. Currently, the use of “master” pressure reducing valves (a single pressure reducing valve that controls the water supply to multiple fire protection systems) is controversial and introduces reliability issues that need further investigation.

C. With a constant speed fire pump, it is frequently impractical to design beyond 110% of the rated flow because of the decline in available pressure. A variable speed pressure limiting control fire pump allows increasing the rated pump pressure and makes it possible to design at 140-150% of the rated flow. This may allow using a fire pump with a lower rated flow, thereby possibly reducing the power requirements and pump cost.

D. Variable speed pressure limiting controlled fire pumps have significant implications on fire pump design, potentially lessening the demand for low churn (<=110%) pumps and allowing the focus to be placed on pump cost and power consumption. Typically, flat curve fire pumps require more horsepower than pumps with steeper curves. Fire protection system designers should work closely with pump system designers to determine the optimal characteristics of fire pumps.

E. With proper design, Variable speed pressure limiting controlled fire pumps can accommodate significant pressure fluctuations in the water supply without compromising the fire protection, or reducing the number of floors served by a variable speed pump. Variable speed pumps also make it easier to provide allowances for possible future degradation in the water supply to be designed into the fire protection

F. A diesel engine is inherently a variable speed driver where the speed is controlled with a throttle The cost differential between a constant speed diesel engine driver and a variable speed diesel engine driver is small. The controller that changes the characteristics of the electricity sent to the motor is relatively costly. In general, the cost of a variable speed diesel engine driver is less than a variable speed electric motor driver.

IX. REFERENCED DOCUMENTS

NFPA 13, *Standard for the Installation of Sprinkler Systems*,
NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*
NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*
NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*