Master Control Systems, Inc.

Variable Speed

Fire Pump Controllers

Meets NFPA 20 - 2022

UL/FM Listed and Approved for fire protections

* Pressure Limiting Control
* Suction Limiting Control

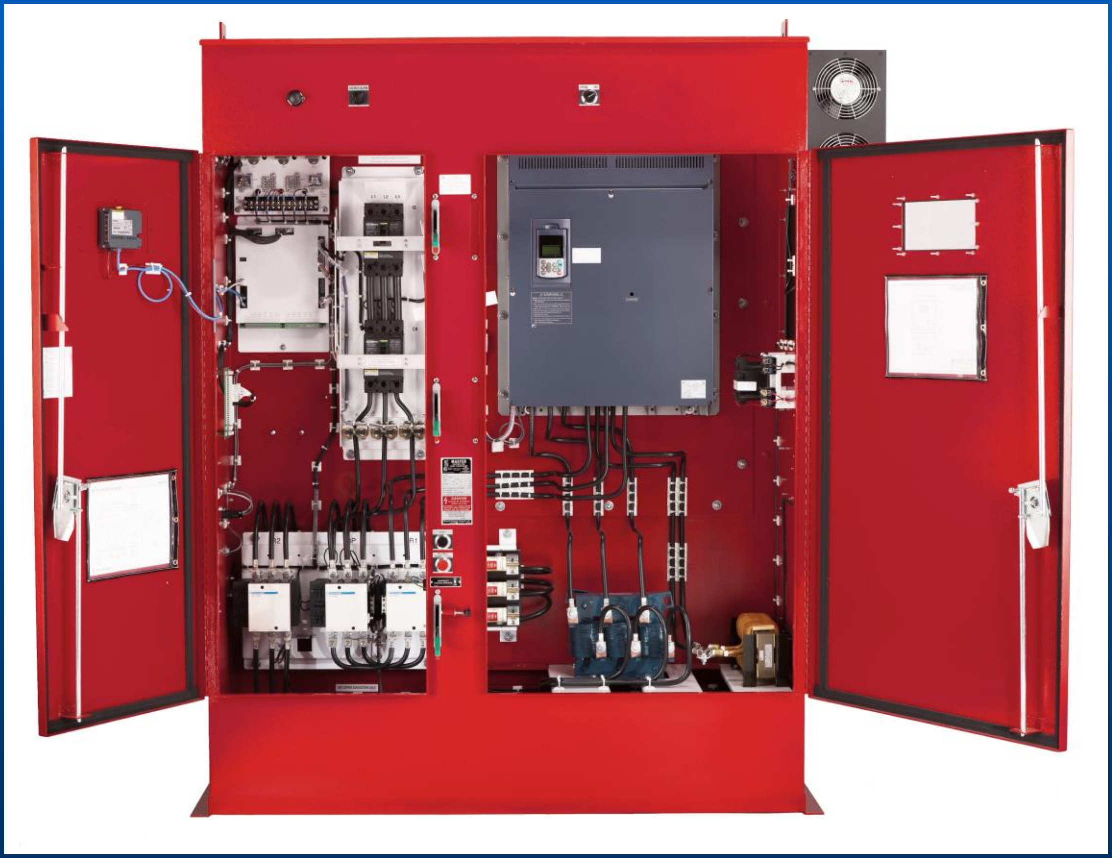
UL

FM APPROVED

So why Variable Speed?

- Pressure Limiting Control
  - Eliminates Pressure Reducing Valves (PRVs)
  - Eliminates related NFPA 25 inspections and testing
  - Eliminates break tanks (saves cost and space)
  - Reduces high pressure piping
  - Reduces pipe sizing
  - Reduces the gen-set size
  - Allows a large water supply safety factor for future growth.
- Suction Limiting Control
  - Eliminates the suction control valve (if required, add 83LT)

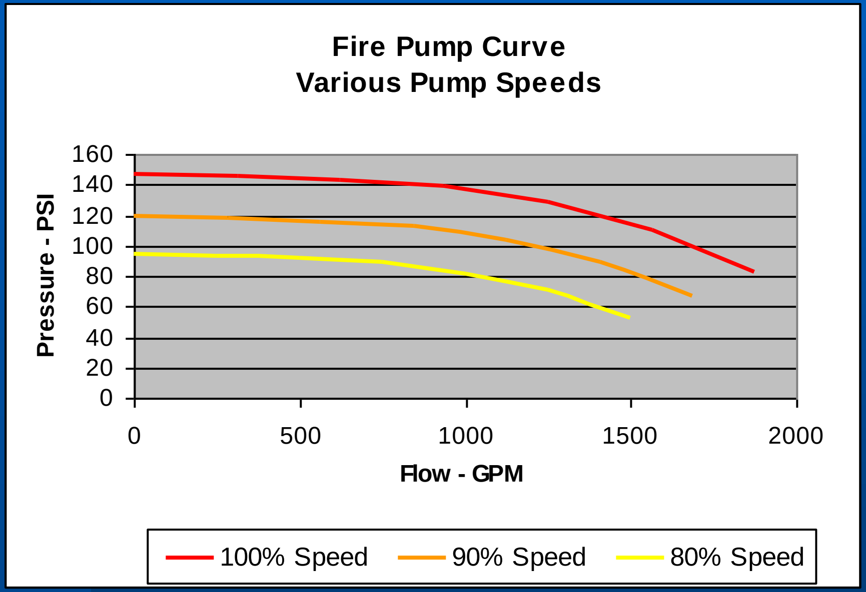
Ok, what does it look like?



Listed and Approved For Fire Protection

Model ECVA-150-46-XG4

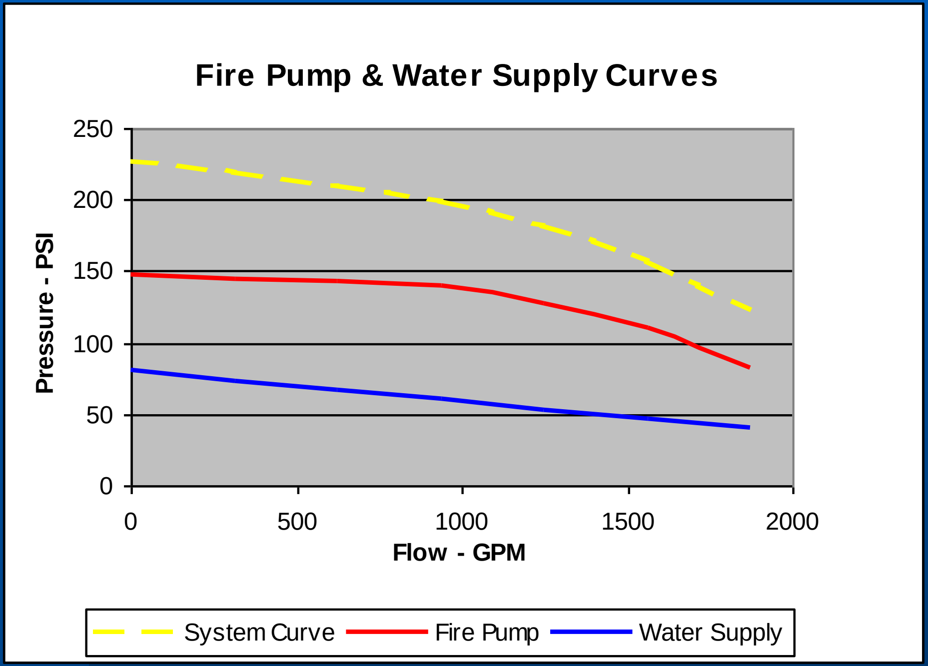
How does it work?



ENGINERING PRINCIPLES

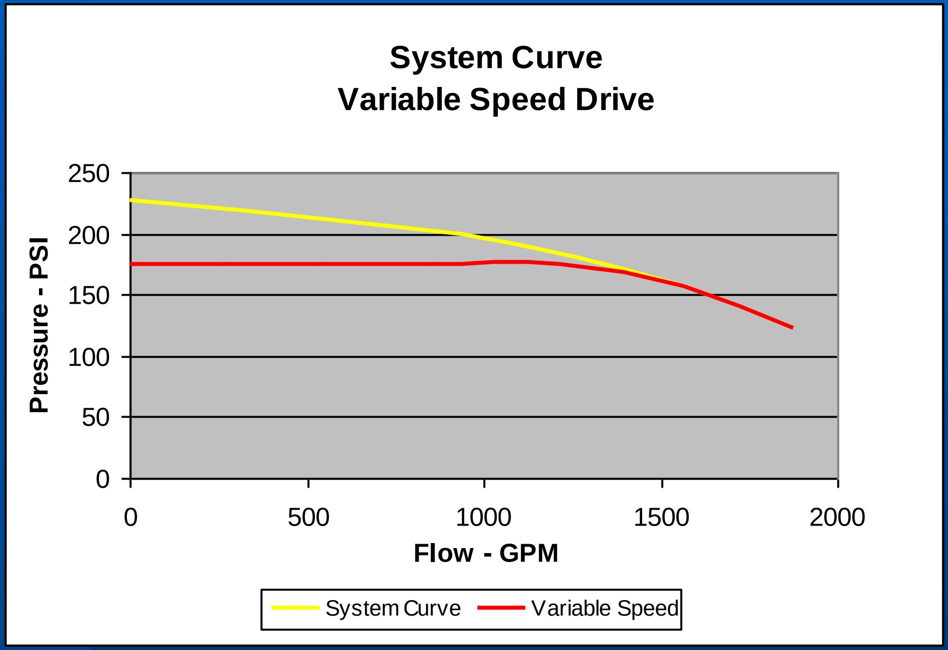
- By changing the speed of the pump, the output pressure can be raised or lowered accordingly to maintain a constant system pressure.
- For a centrifugal pump, the pressure varies by the square of the speed. For Example, if a pump produces 100 psi at rated speed, it will produce 64 psi at 80% speed.

Engineering principles



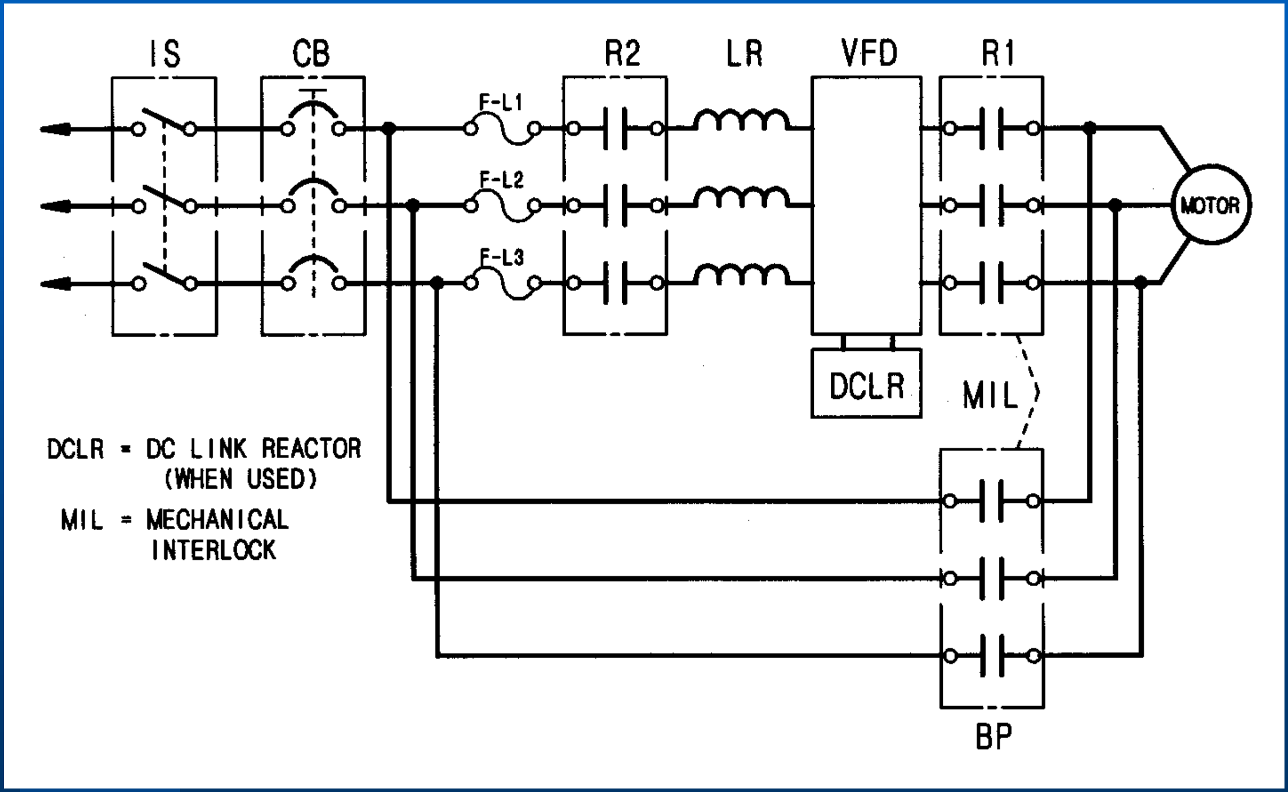
- The water supply curve (blue) and the fire pump curve (red) add together to make the system supply curve (yellow).
- As you can see, the pressure on the system under low flow conditions far exceeds the standard 175 psi ratings of most components.

Engineering principles



- So by controlling the speed you can regulate the pressure to any value under the 100% speed system curve, regardless of flow.
- Thus, the design point can be very close to the maximum system pressure allowed.

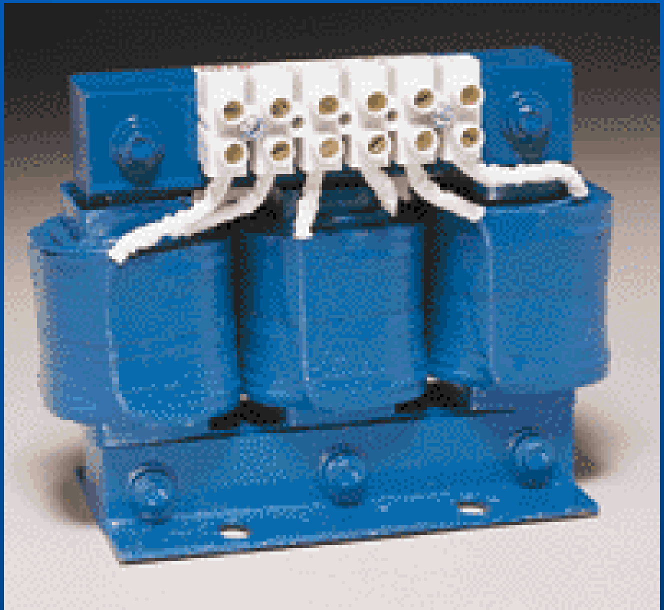
But is it Reliable? Yes!



Our design is totally redundant.

The variable speed drive is automatically isolated and bypassed by the traditional fire pump controller, if needed.

5% Line Reactance for VFD



- Reduces RMS line currents
- Reduces effects of line transients
- Reduces harmonic distortion

So How Does it Operate?

- The controller is started when the pressure drops below the “start pressure”, just like with an ordinary fire pump controller.
- Once started, the VFD powers up and begins regulating the motor speed to maintain the “set pressure”. If the VFD “Ready” signal is not received in 5 seconds, the VFD will be bypassed.
- If the system pressure is not high enough to exceed the “bypass reset pressure”, the controller will bypass the VFD within 15s.
- If the system pressure drops below the “bypass pressure” while running for more than 15s, the VFD is bypassed.
- Once bypassed, the controller will continue running in the bypass mode until manually or automatically stopped, depending on the setting.

Summary of Pressure Settings

Pump Room Settings

- In the automatic stop mode, the jockey reset pressure must be above the VFD set pressure to send the VFD to it's minimum speed before auto stop can occur. Note: Unlike normal VFDs, we don't slow down the fire pump to see if water flow exists. This would drop the pressure on a fire hose during a fire.
- VFD set pressure must be above the fire pump controller Bypass Trip setting to turn off the VFD failure timer.
- The VFD running bypass should be set below the 150% flow discharge pressure and above the maximum static suction pressure.

High Rise Building Application

- If your building is over 75’ tall it’s classified as a High Rise building by NFPA 14.
- Most jurisdictions will require a class 1 standpipe system and an automatic sprinkler system.

Standpipe System

- Now with the variable speed controller, you can raise the maximum height or zone to 150 feet without the use of PRV's.

  175 psi under any conditions

  – 100 psi FD requirement

  – 10 psi riser friction loss (0.067 psi/ft)

  =====

  65 psi x 2.31 ft/psi = 150 feet.

- *<u>Finally a realistic PRV free building!</u>*

Automatic Sprinkler Systems

- When a combined sprinkler and standpipe system is used, the sprinkler system is subject to the same pressure as the standpipe system.
- Before variable speed controllers, PRV’s were used to also keep the sprinkler system pressure to 175 psi or below.

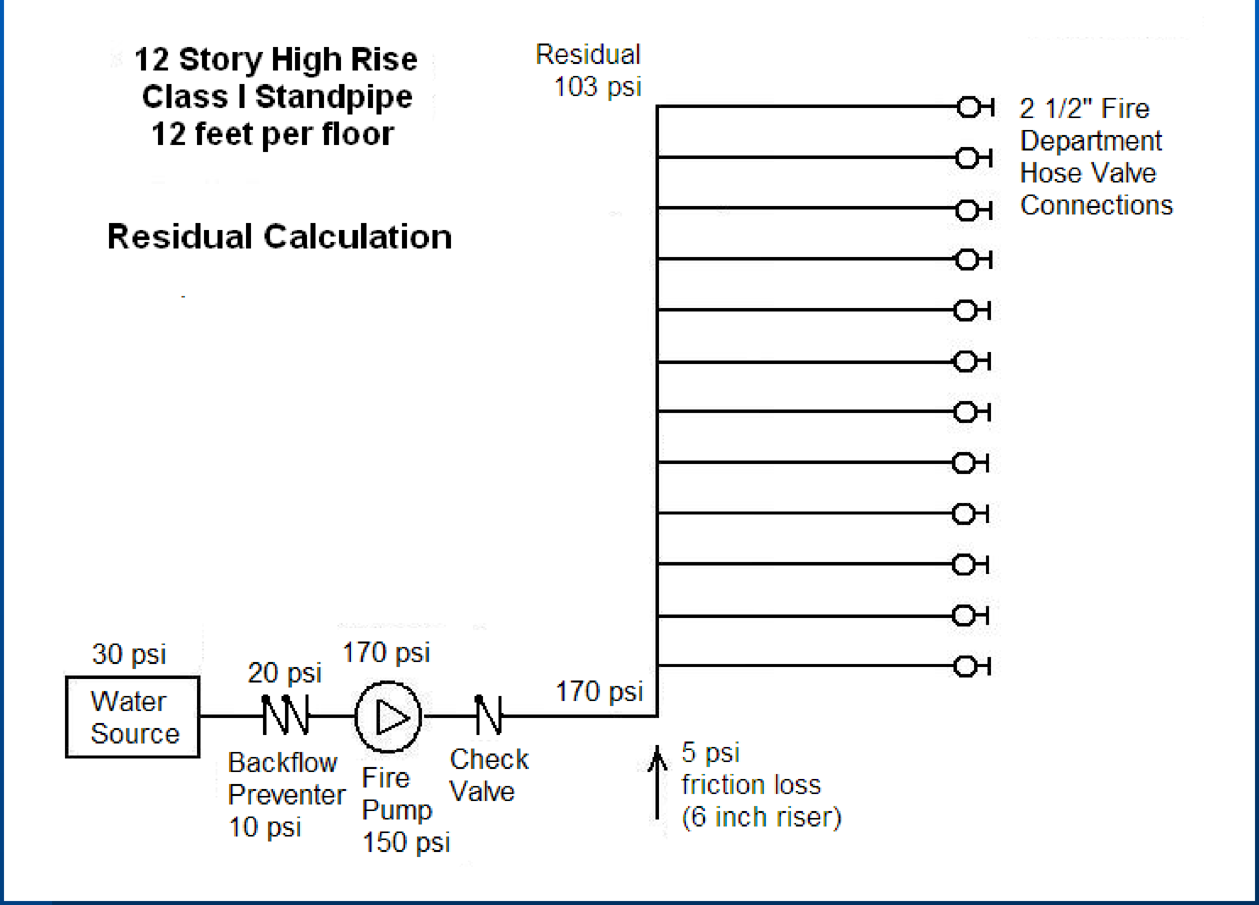
High Rise Calculations

- Let’s calculate a 12-story,144 foot, large footprint, high rise building with 12 feet per floor.
- It will have:
  - 4 stairways
  - 2 sprinkler design areas per floor.

High Rise Calculations

- With 4 stairways, the required gpm will be 500 for the 1st and 250 for the others. This adds up to a total of 1250 gpm. For a combined system, only 1000 gpm is needed.
- Ideally, the pump pressure is based on the elevation of the building, plus 100 psi on the roof for the Fire Department connection less the residual pressure of the water source. However, the friction loss of the standpipe and the backflow preventer must also be added.
- So if the elevation pressure is 62 psi and the residual pressure is 30 psi, the ideal pump pressure is 132 psi. However, we need to add 5 psi for the standpipe loss and 10 psi for the backflow preventer so the nearest pump size will be 1000 gpm at 150 psi.

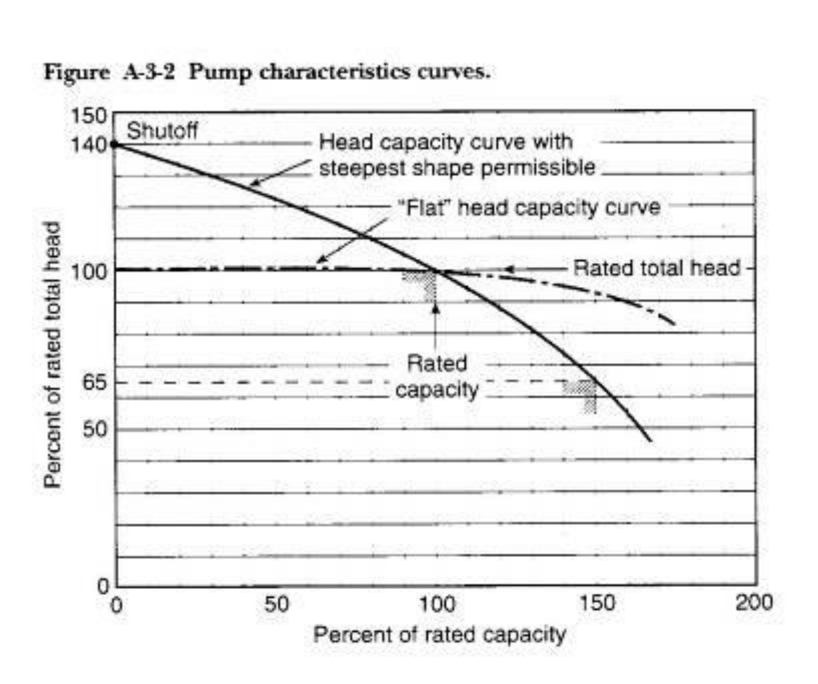
Residual Calculations – 144 feet



Static Conditions

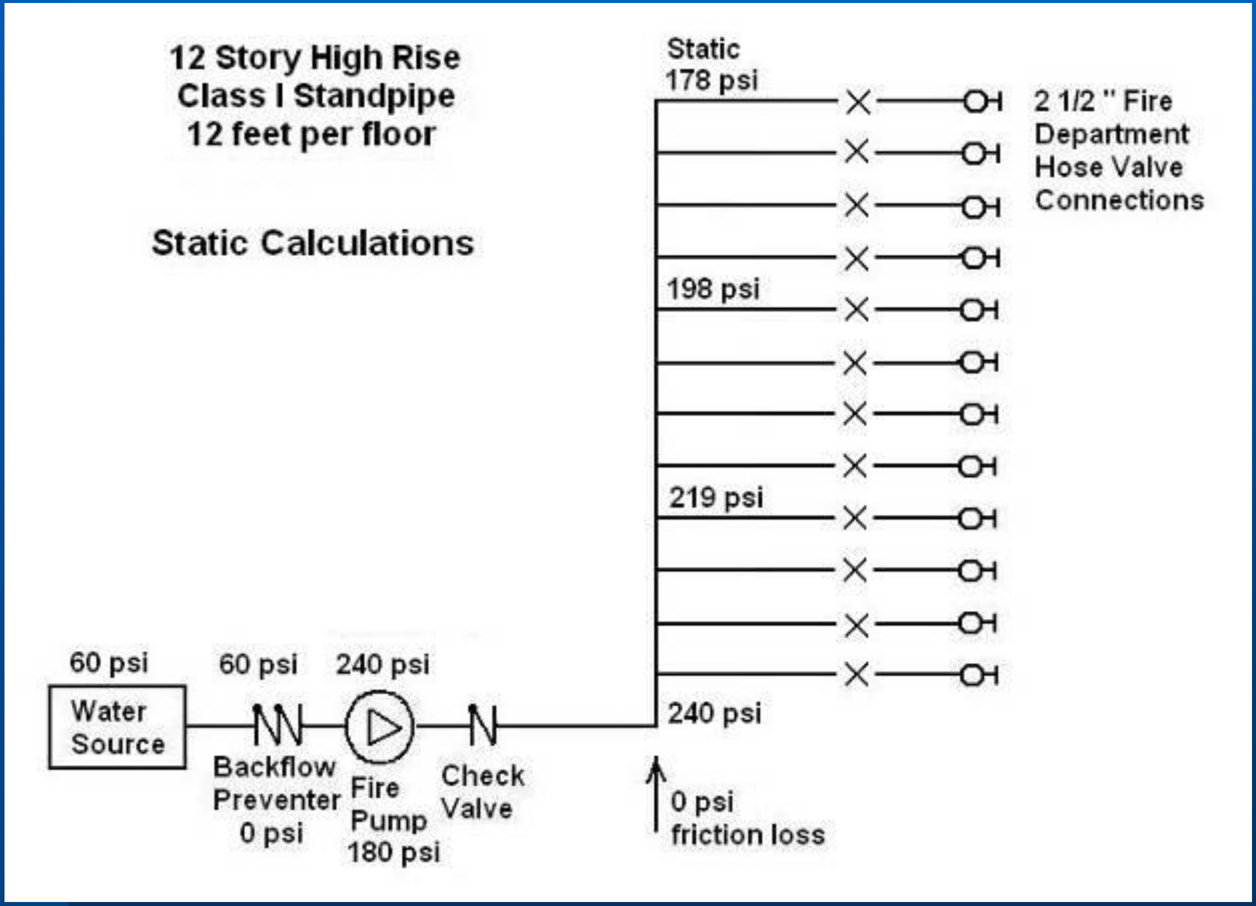
- This looks good so why do we need variable speed if the maximum pressure is 170 psi?
- Because of the high discharge pressure at no-flow during testing or a low flow fire conditions.
  - Static water source higher
  - No drop in backflow preventer
  - Pump running at shutoff is higher
  - No friction loss in pipes

Static Overpressure



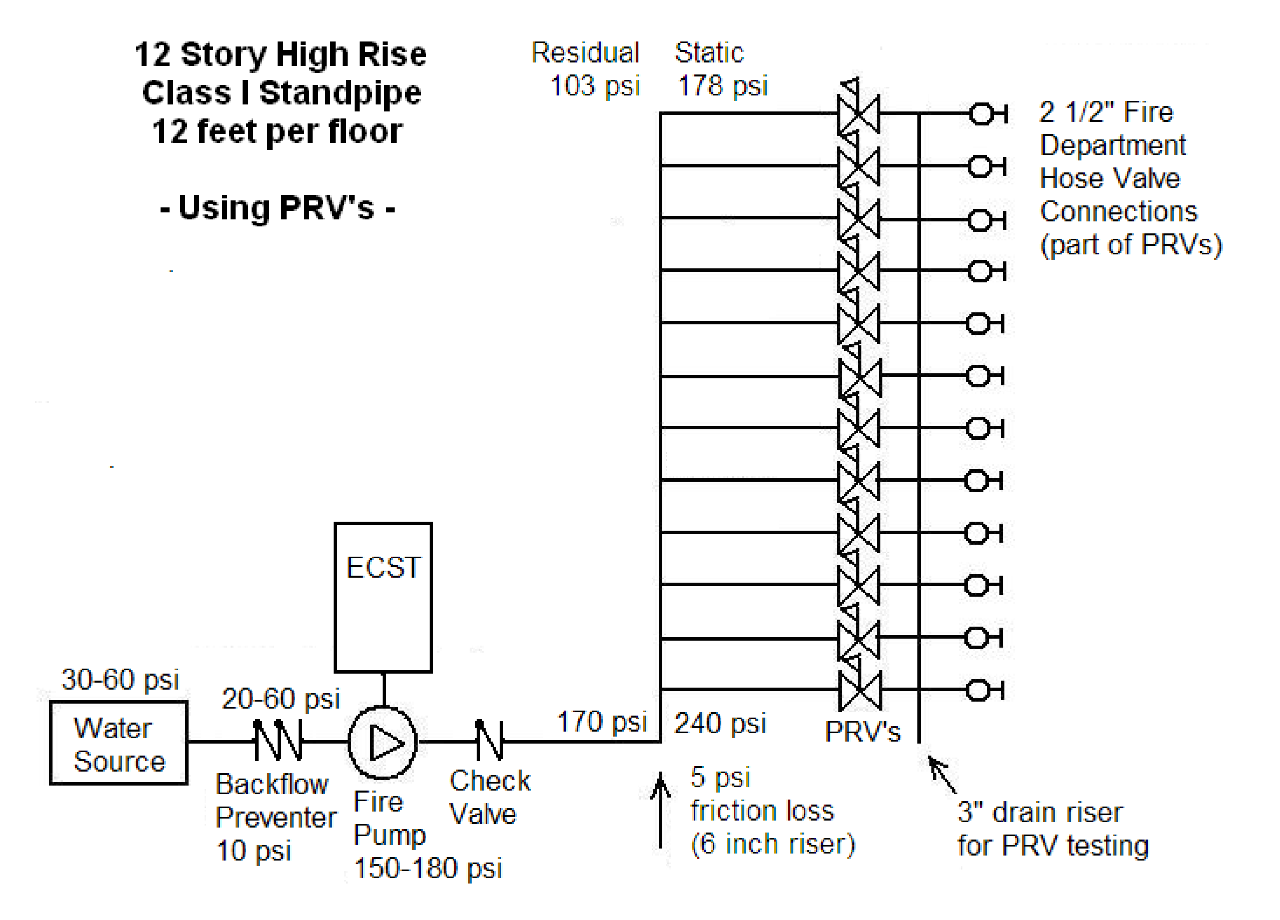
- In this case, the pump adds 30 psi at shutoff.
  - Note: The max shutoff pressure per NFPA-20 is 140% which could add as much as 60 psi.
- The city supply adds 30 psi from residual to static.
- The backflow preventer adds 10 psi from residual to static.
- Adding these to the residual design pressure of 170 will produce a total static system pressure of 240 psi.

Static Calculations – 144 feet



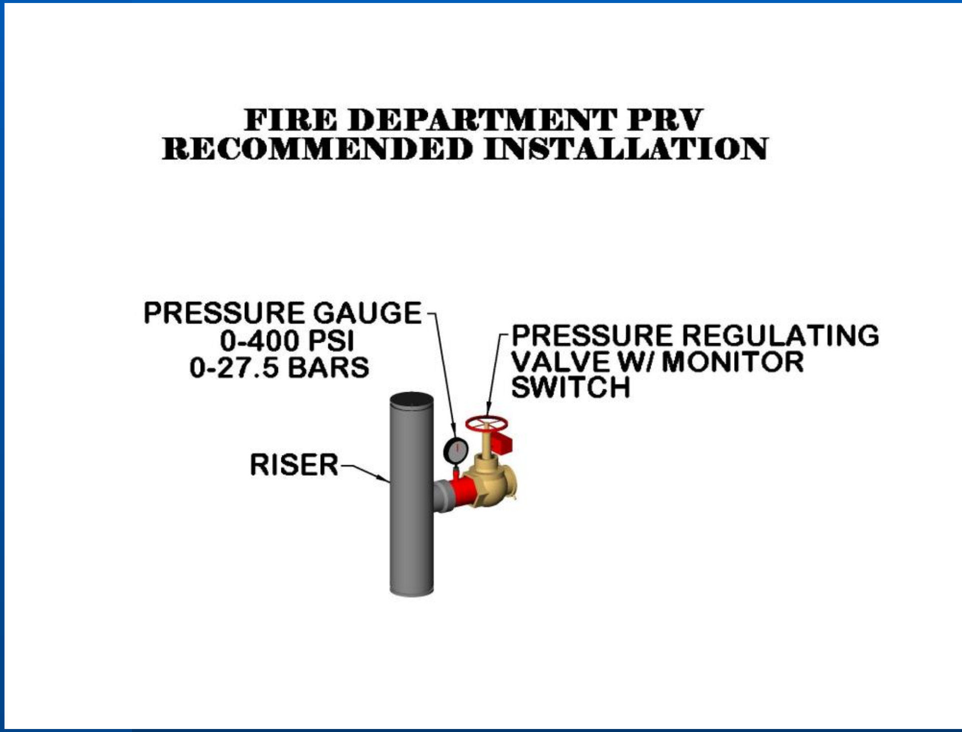
Pressures are too high on all 12 floors.

12 Story Conventional Design Solution



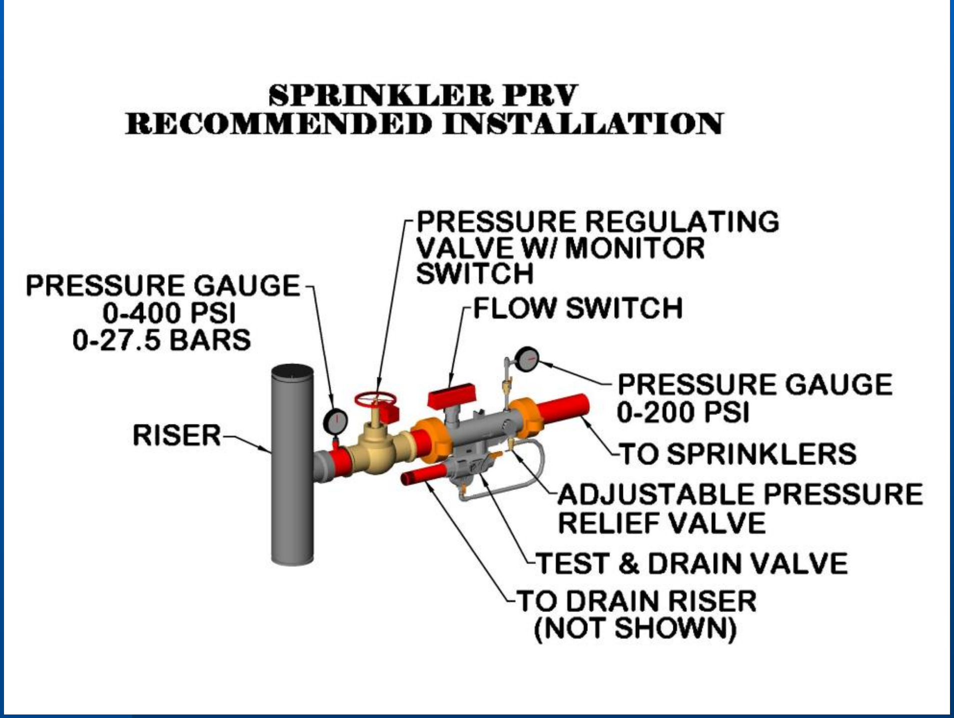
All 12 floors require PRVs.

12 Story Conventional Design Detail



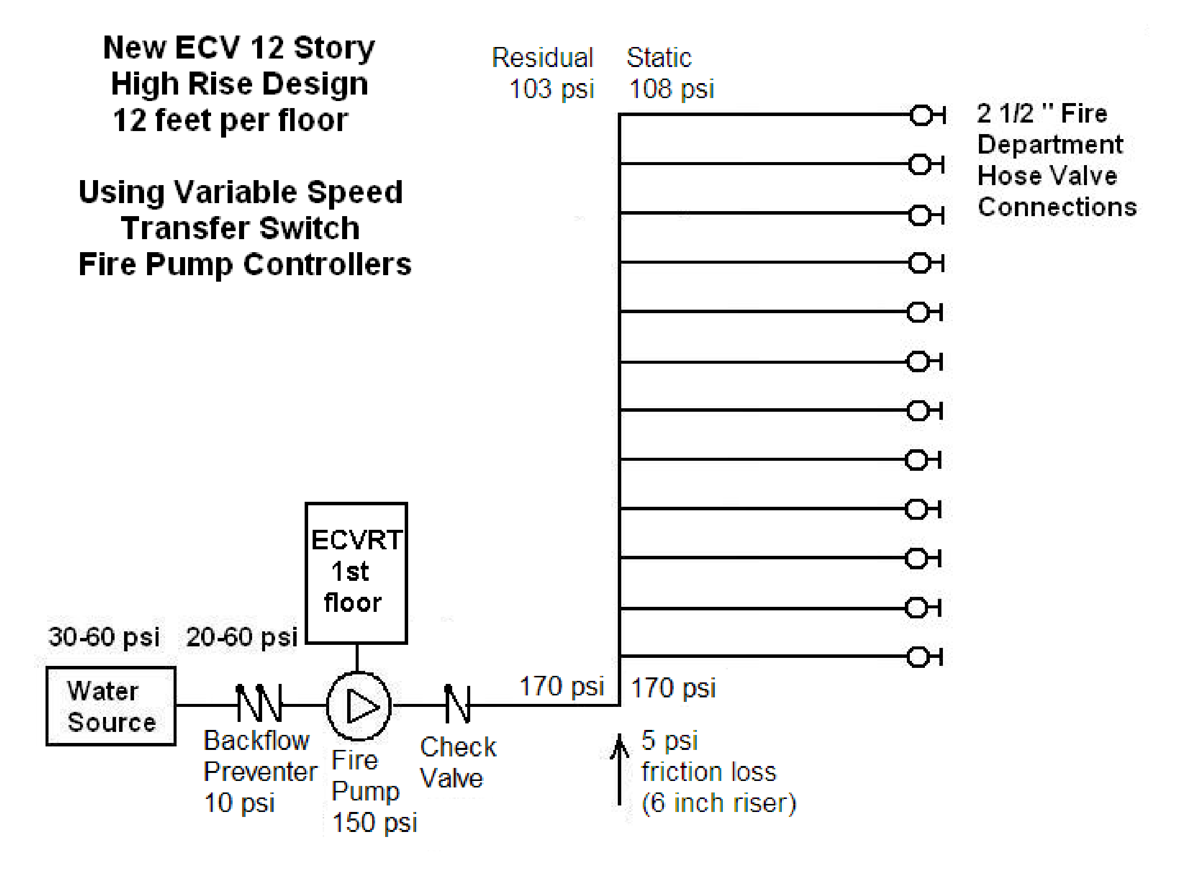
- Fire Department PRV's typically require:
  - Input Pressure Gauge
  - Monitor Switch
  - 2 ½" Cap and Chain
- 3" drain riser (not shown)
- NFPA 25 Requires:
  - Quarterly Inspections
  - Annual partial flow test
  - 5-year full flow test

12 Story Conventional Design Detail



- Sprinkler Control PRV's typically require:
  - Input pressure gauge
  - Output pressure gauge
  - Small relief valve
  - Flow switch
  - Tamper switch
  - Connection to 3 inch drain riser (not shown)
- NFPA 25 Requires:
  - Quarterly Inspections
  - Annual partial flow test
  - 5-year full flow test

New 12 Story ECV Solution – 144 feet



With a Master model ECVRT, variable speed transfer switch fire pump controller, the output pressure of the fire pump is controlled to precisely 170 psi under all flow conditions.

Owner's Cost - 12 Story Conventional Design

Direct construction costs

• PRV's, labor and related costs ($1,020 /FD PRV x 48, $1,140/ FC PRV & Accy's x 24)	$76,320
• 3" Drain risers (2 x $40/ft x 144 + 2 x $20/ft x 144)	$17,280
• Extra design and management time ($200/hr x 40hr)	$ 8,000
• Initial PRV testing (72 x 1.0hr x $150)	$10,800
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	$112,400

NFPA 25 testing costs for life of building (20 years)

• Qtrly Inspect (3 x 24 x .25hr x $150/hr x 20)	$54,000
• Annual Test (72 x .5hr x $150/hr x 16)	$86,400
• 5-Year Full Flow (72 x 1.0hr x $150 x 4)	$43,200
• PRV repair costs (72 x 5% x $1,140 x 20)	$82,080
	=========
	$265,680

Note: Average annual testing cost is $13,284.

Note: Most of this testing is done on overtime, but this is not included.

Owner's Cost - 12 Story ECV Design

Direct construction costs

- Variable Speed Upgrade (150 hp, 460 v)	$62,780
- Bypass Relief Valve (6 inch)	$ 6,000
	=======
	$68,780

Total costs

- Direct construction savings ($112,400 – $68,780)	$43,620
- Potential Gen-set savings ($300/kw*150 kw)	$45,000
- Long term NFPA 25 cost savings	$265,680
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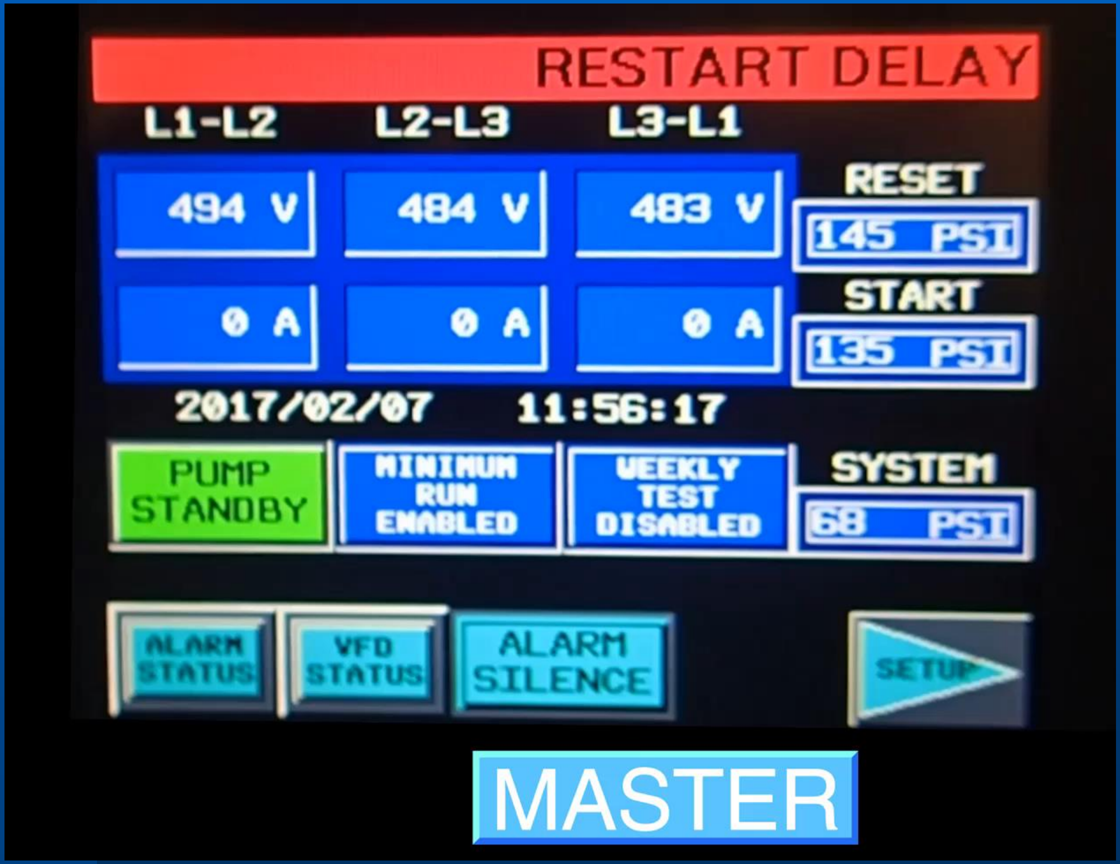
	$354,300

Total savings to the owner are <u>$309,300 to $354,300</u>

ECV Job Videos



Now with advanced digital control

Starting with no flow

(Set Pressure = 150)

ECV Job Photos

ECV Photos – cont’d

ECV Photos – cont’d

ECV Photos – cont’d

Model ECVST-350-46-XG4,SIS

Variable Speed Application Guidelines

- The motor should be Listed for fire pump service, be suitable for inverter duty applications, and marked accordingly.
- Based on NFPA 20-2019, the <u>Service Factor can be used for inverter duty</u>, if the motor is marked accordingly. Not all motors are rated as such, so contact the manufacture for verification and marking.
- If the Service Factor is used, the current rating of the VFD may need to be increased. Contact Master to determine if this is needed.
- A main relief valve will be required, unless the discharge pressure does not exceed the rating of the system components in the bypass mode at no flow.

Gen-Set sizing

- Variable Frequency Drives with 5% input line reactance provides the best form of motor starting for the gen-set.
- The starting current drawn by the VFD is about 125% of the motor FLA while still producing 100% starting torque.
- When using a VFD, the voltage drop in the bypass mode can be greater than 15% per NFPA 20-9.4.3

Gen-set Sizing Example

- NFPA 20 requires that the voltage drop shall not exceed 15% during starting. For closely sized applications, this typically requires the gen-set to be 2-3 times larger than normal; however, since the VFD inrush is so low and provides 100% starting torque, the gen-set may be smaller.
- Based on a typical application for a 150 hp motor utilizing soft start, a gen-set manufacture’s sizing program would select a 300 kW gen-set.
- For the same application, utilizing a variable frequency drive, the program would select a 150 kW gen-set.
- This saves 150 kWs and <u>cuts the gen-set size in half!</u>
- But before we pocket this savings, let’s check the voltage drop in the bypass mode.

The Gen-set and the Bypass mode

- As standard, the bypass mode uses full voltage starting. This may be fine for large gen-sets, but for tightly sized gen-sets, reduced voltage primary reactors or soft starters are available.
- With the Master primary reactor bypass, the gen-set sizing can be the same as with the VFD!
  - This is based on our primary reactor bypass design that guarantees hold-in with a 35% voltage drop. Thus, the gen-set can be sized for a 25% gen-set voltage dip during starting (NFPA 20, paragraph 9.4.3).
  - Caution: Typical soft starters are only rated for a minimum operating voltage of 85% of the control power input voltage, so they may not be suitable for use when the voltage drop is greater than 15%.

ECVRT with Transfer Switch

- Left bay is the FPC Section
- Middle bay is the Tsw Section
- Right bay is the VFD Section.

The Variable Speed Advantage

- Creates a PRV free building
- Eliminates NFPA 25 testing of PRVs
- Eliminates break tanks
- Eliminates NFPA 14 larger drain riser
- Requires fewer high pressure fittings
- Allows smaller pipe sizes
- Reduces the gen-set size
- Allows large water supply safety factor

- And the best part of all, you have a redundant, more reliable system for better fire protection and life safety!

Master Control Systems, Inc.

Thank you!

And remember, there *is* a difference…

MASTER, *The intelligent choice*