Master Control Systems, Inc.

Variable Speed

Fire Pump Controllers

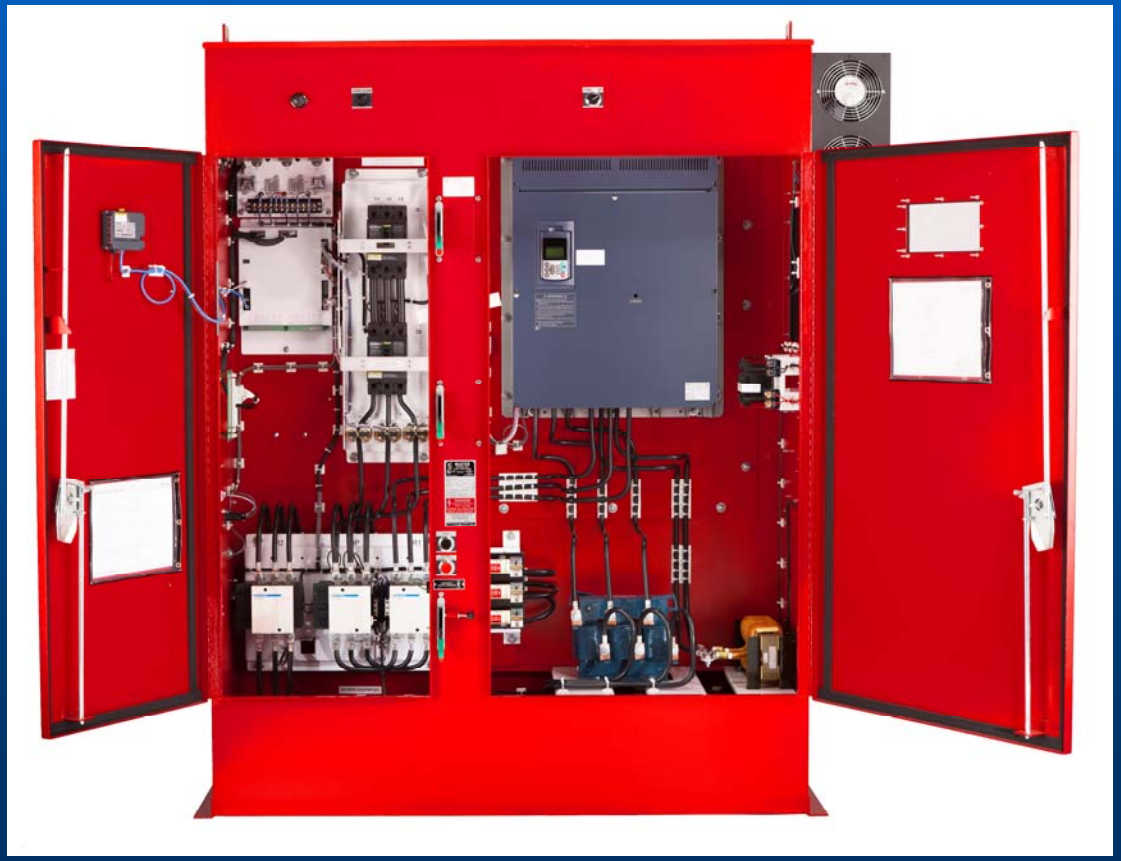
Meets NFPA 20 - 2013

UL/FM Listed and Approved for fire protections

Why Variable Speed?

- Huge Sprinkler System and Standpipe Cost Savings can be obtained while increasing the reliability of the system!
  - 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
  - Reduces utility demand charges
  - Can add a water supply safety factor for future growth without affecting the design.

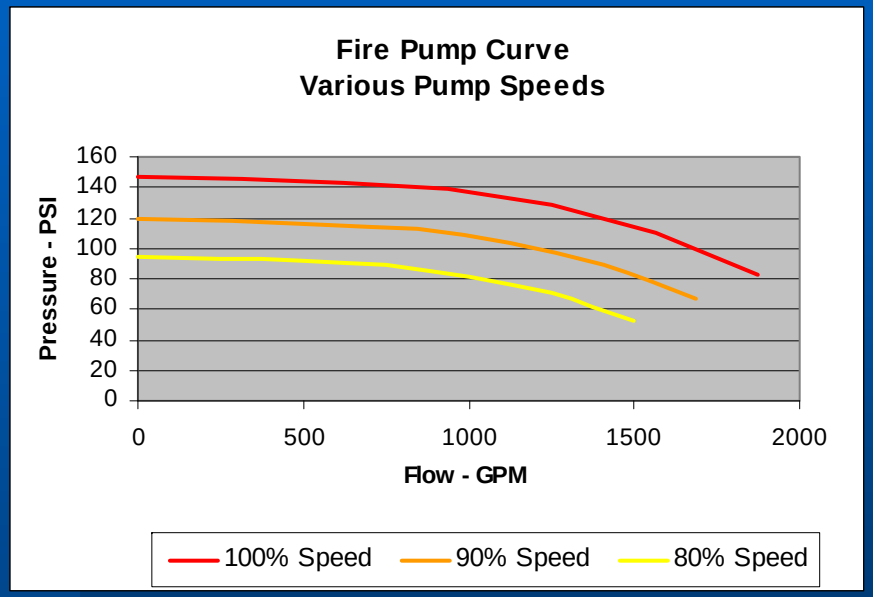
Ok, what does it look like?



Model ECV-150-46-XG4

Listed and Approved For Fire Protection

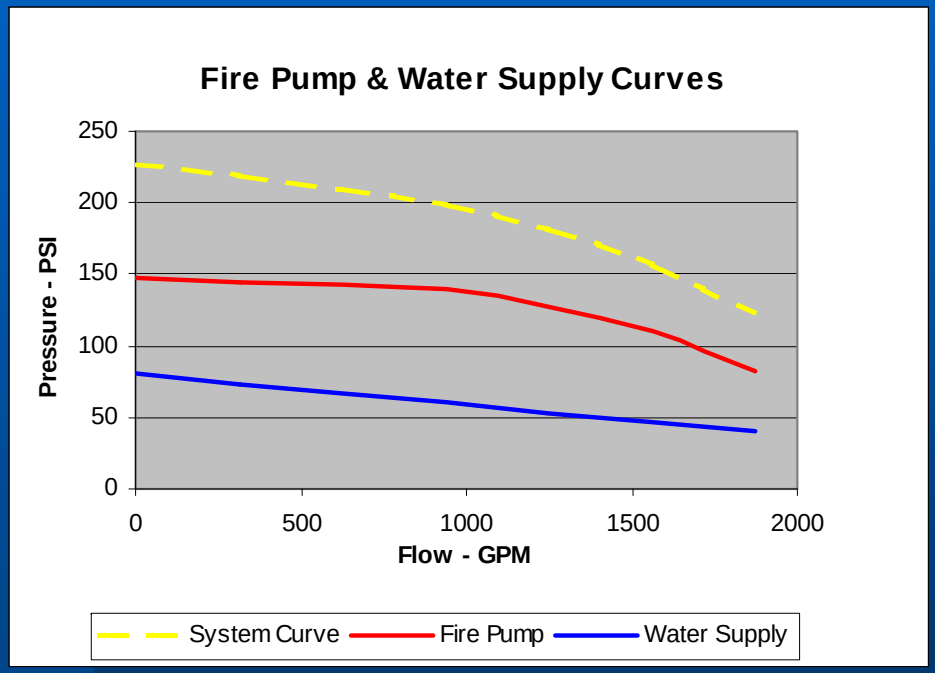
So how does it work?



ENGINERING PRINCIPLES

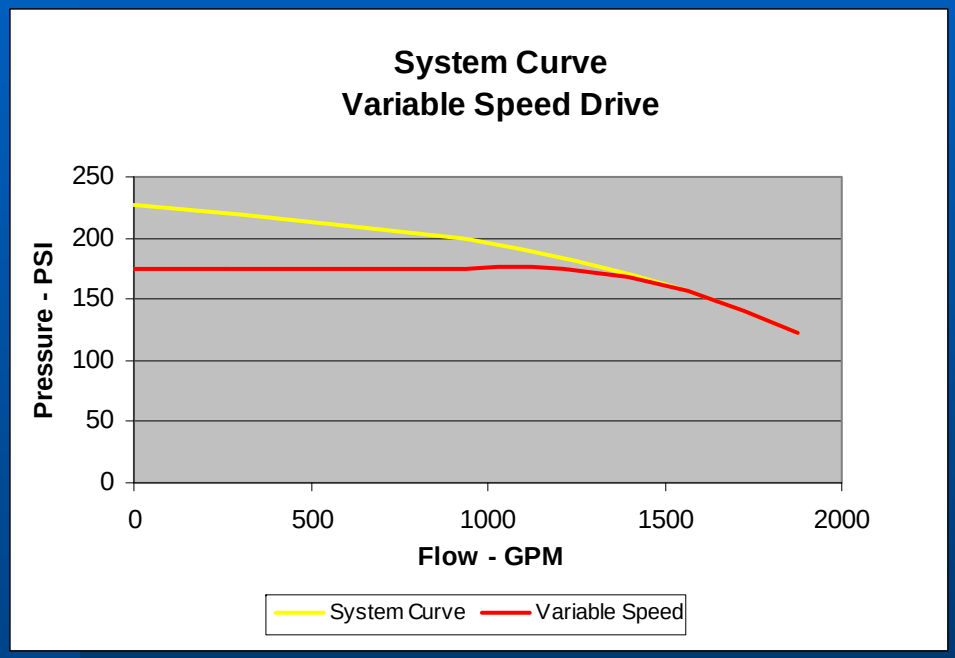
- By changing the speed of the pump, the output pressure can be raised or lowered accordingly to maintain a constant system pressure.
- For a centrifugal pump, the pressure varies by the square of the speed. For Example, if a pump produces 100 psi at rated speed, it will produce 64 psi at 80% speed.

Engineering principles



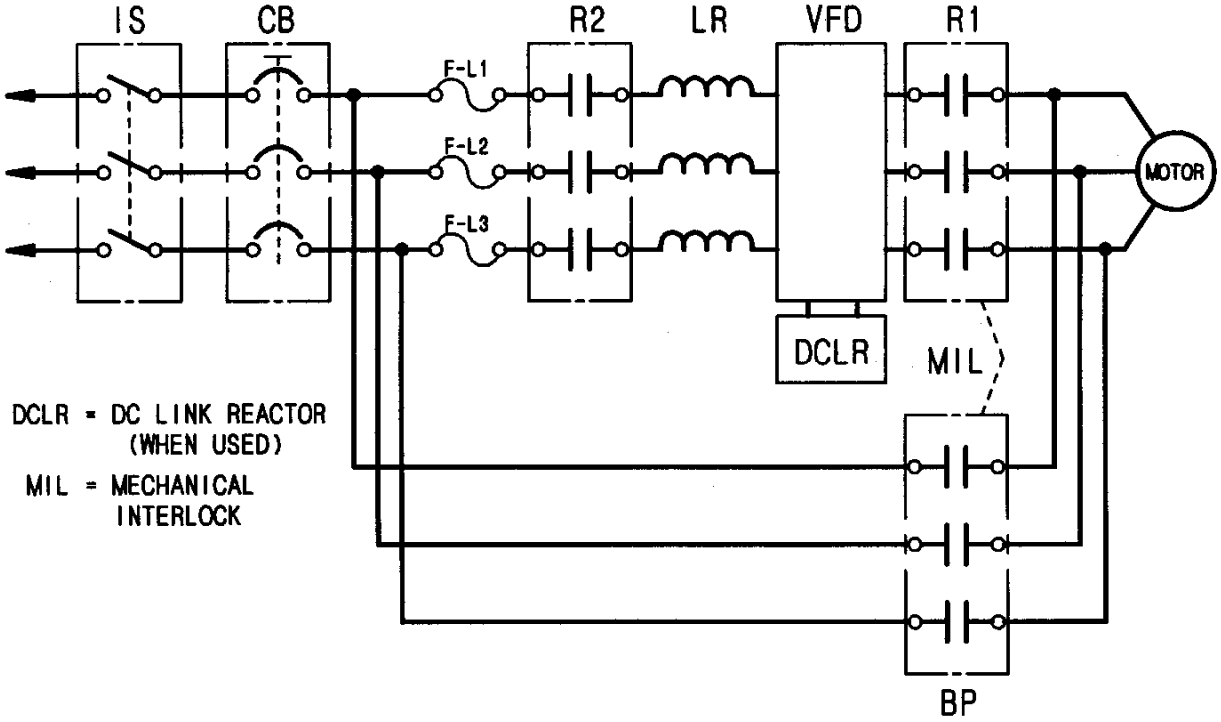
- The water supply curve (blue) and the fire pump curve (red) add together to make the system supply curve (yellow).
- As you can see, the pressure on the system under low flow conditions far exceeds the standard 175 psi ratings of most components.

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!



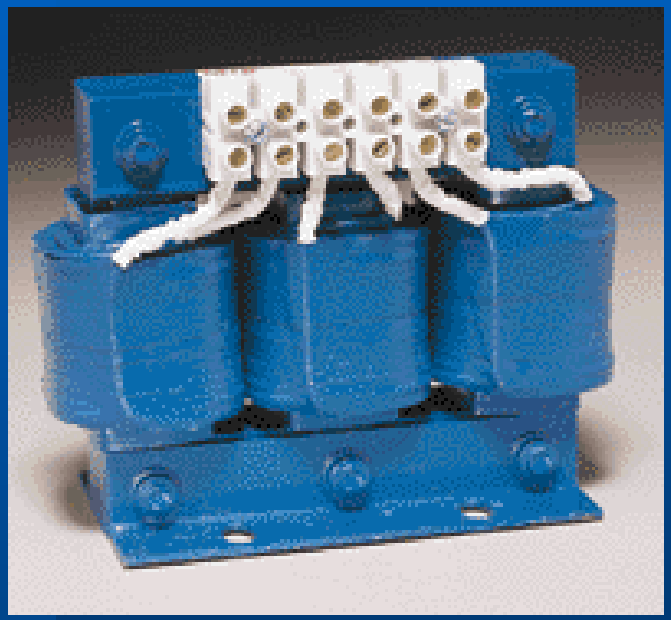
Our design is totally redundant.

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

Load and Line VFD Isolation

- Load isolation is added to disconnect the motor from the VFD before connecting it to the traditional fire pump controller.
- Line isolation is added to increase the life of the VFD as well as to reduce the exposure to service entrance line transients.

5% Line Reactance for VFD



- Reduces RMS line currents.
- Reduces effects of line transients.
- Reduces electrical line noise.

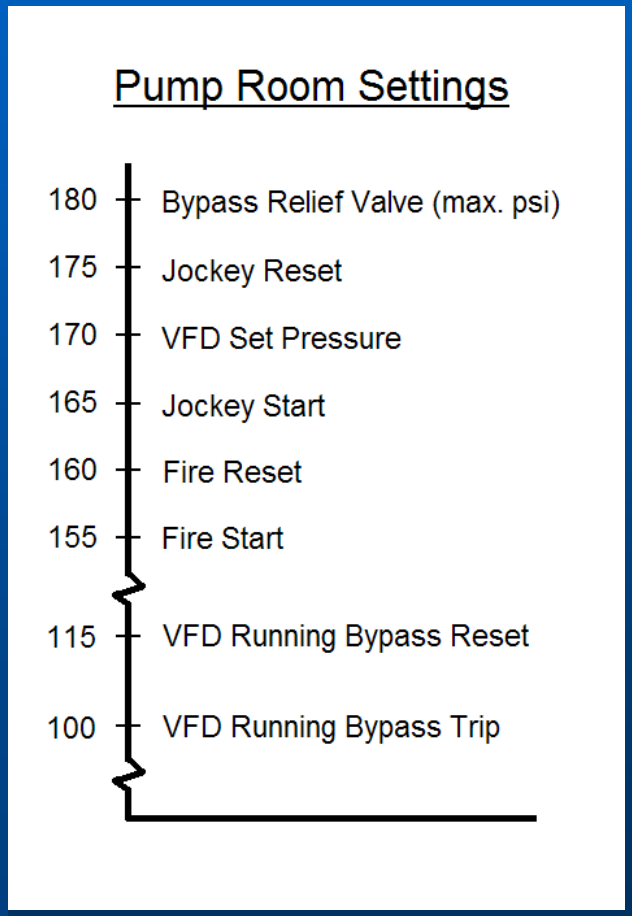
VFD Line Side Fusing

- Fusing is added in the VFD power path to protect the traditional fire pump controller circuit breaker from tripping due to a fault in the VFD power path.
- This fusing is bypassed in the traditional fire pump controller power path.

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 “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 reset.

Summary of Pressure Settings



- The jockey reset 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 reset to turn off the VFD failure timers.
- The VFD running bypass should be set below 65% of the set pressure and higher than the max. 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)

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  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.

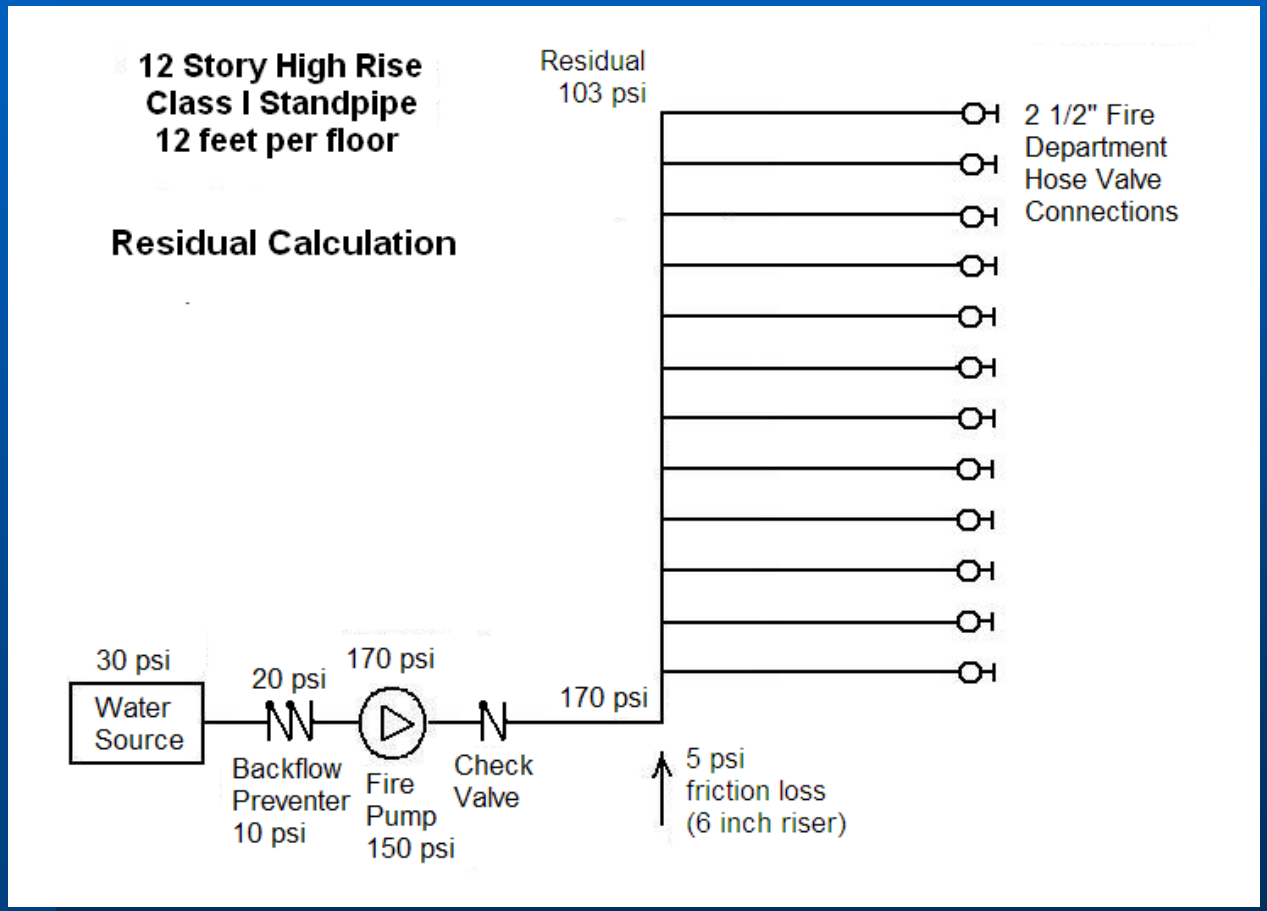
High Rise Calculations

- 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 63 psi and the residual pressure is 30 psi, the ideal pump pressure is 133 psi. However, we need to add 3 psi for the standpipe loss and 10 psi for the backflow preventer so the nearest pump size will be 1000 gpm at 150 psi.

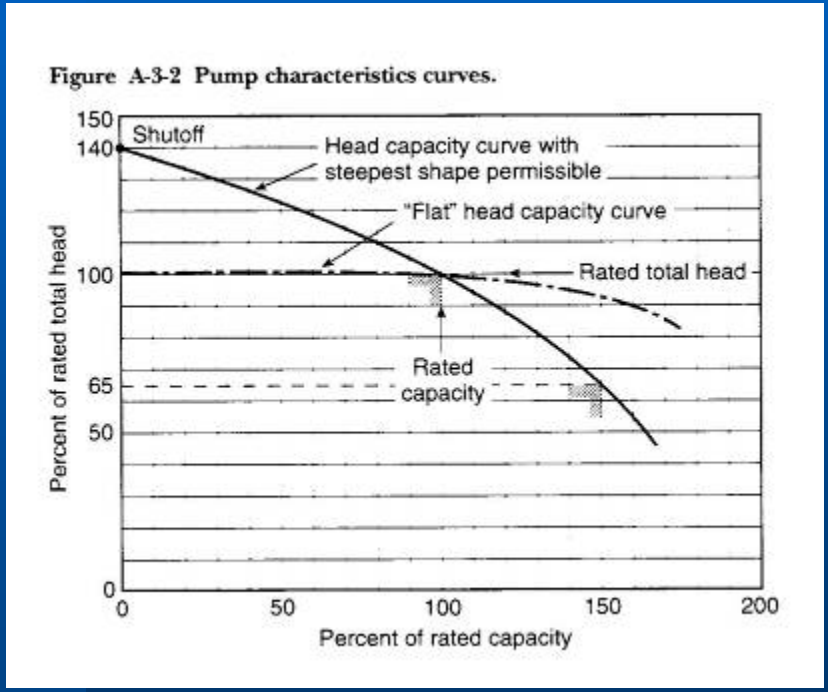
Residual Calculations – 144 feet



Static Conditions

- This looks good so why do we need variable speed if the maximum pressure is 170 psi?
- Because of the high static or 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

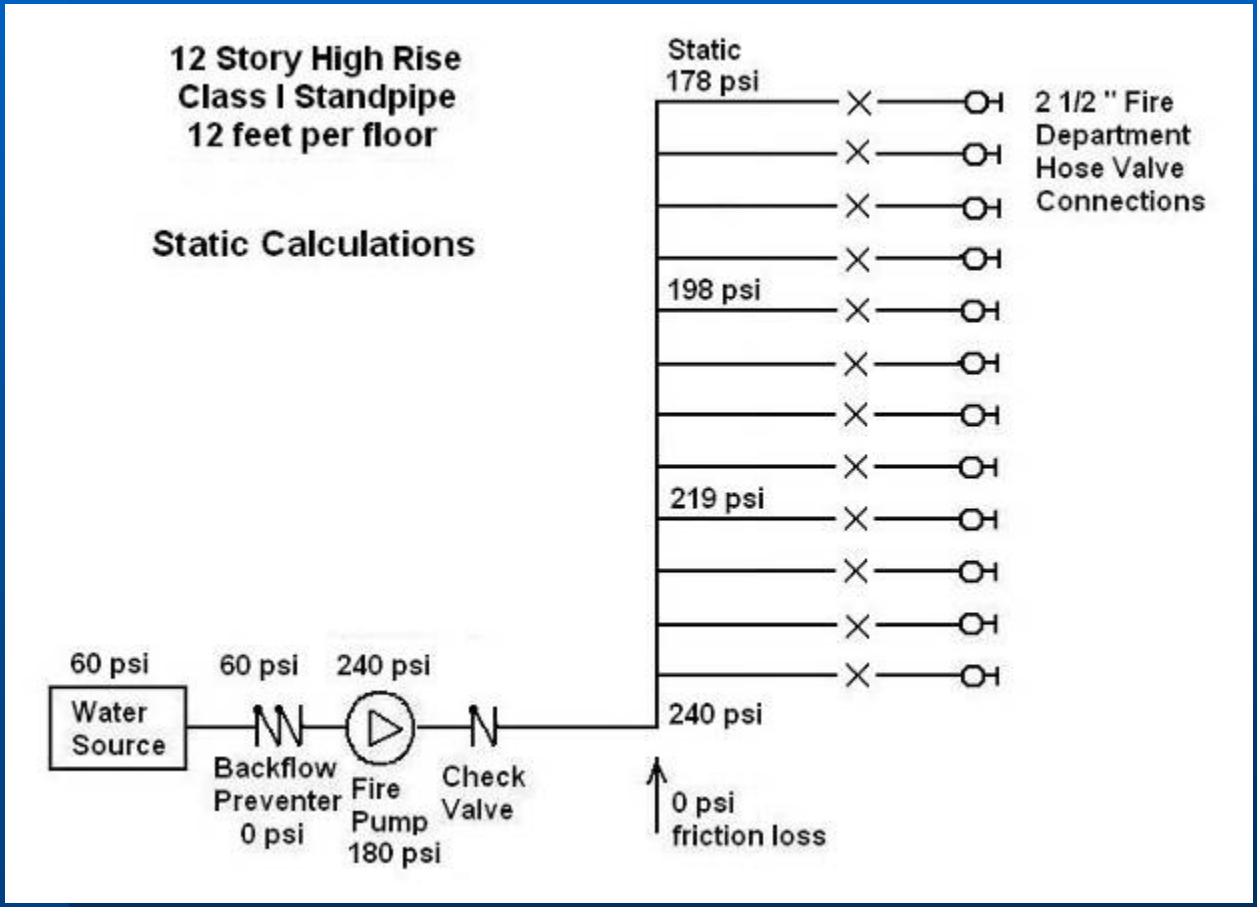


- In this case, the pump adds 30 psi at shutoff.

  Note: The max shutoff pressure per NFPA-20 is 140% which could add as much as 62 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

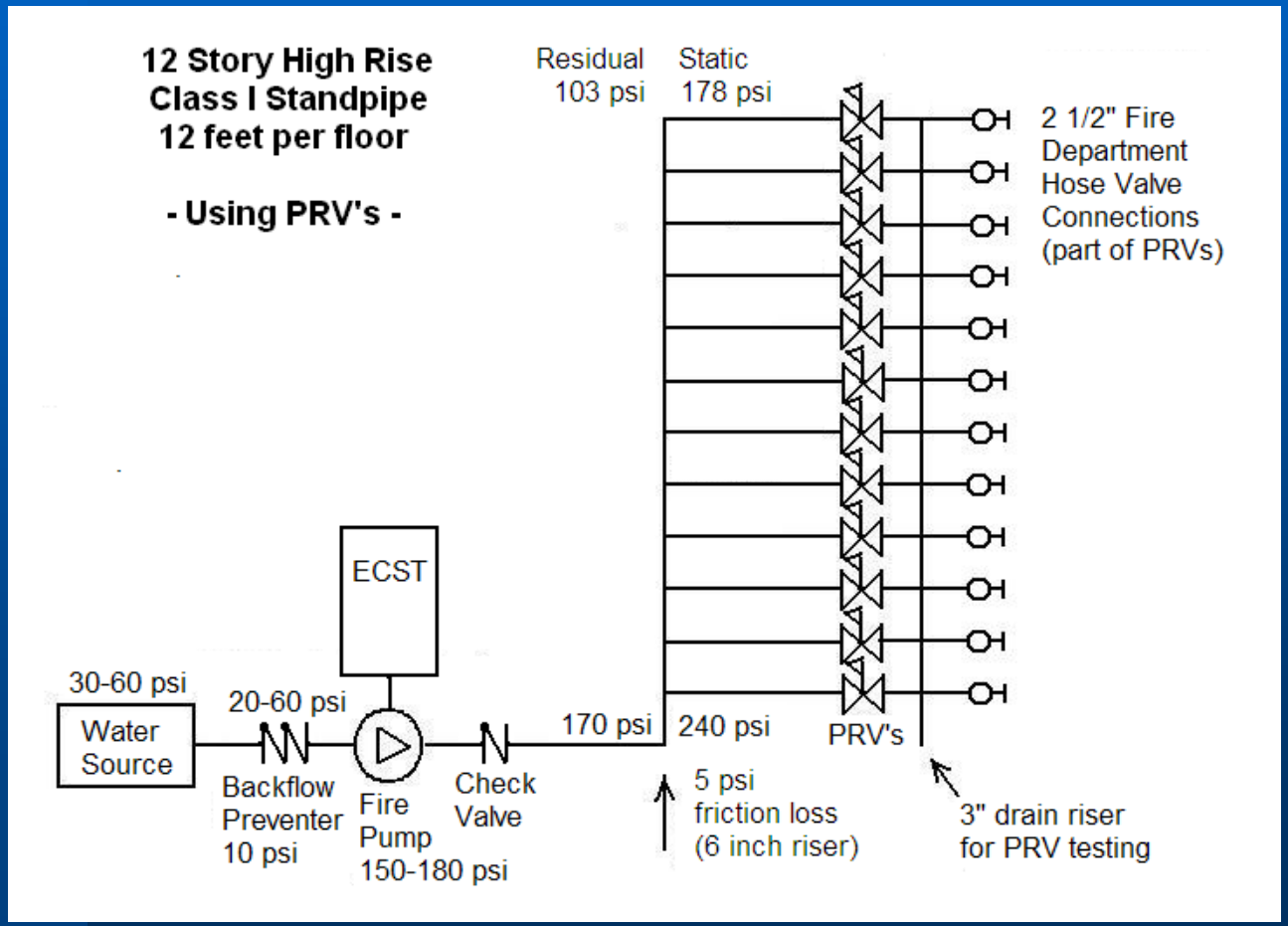


Pressures are too high on all 12 floors.

12 Story Conventional Design Solution

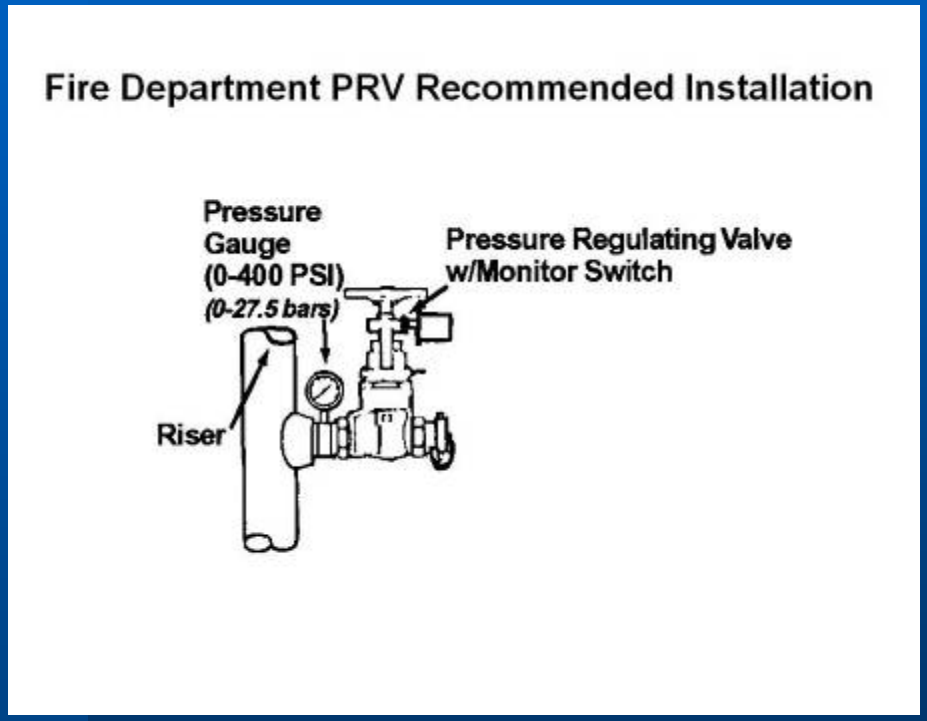
- Add PRV's, Pressure Regulating Valves, high pressure fittings, and drain risers from the 12th floor down. This amounts to:
  - 48 Fire Department PRV's (12 per stairway x 4)
  - 4 Three inch drain risers (1 per stairway)
  - 24 Floor Control PRV's (1 per sprinkler design area x 2)
  - 24 Relief valves and piping for the sprinkler PRV's

12 Story Conventional Design Solution



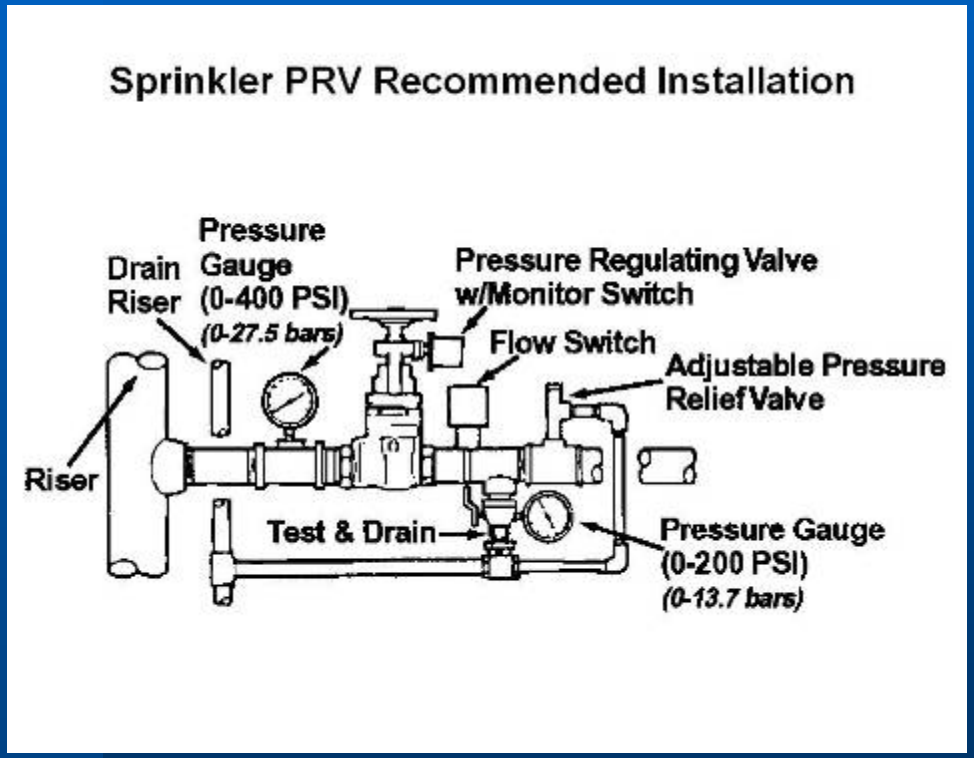
All 12 floors require PRVs.

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

12 Story Conventional Design - Owner Costs

• PRV's, labor and related costs ($857 /FD PRV x 48, $940/ FC PRV & Accy's x 24)	$63,696
• 3" Drain risers (2 x $30/ft x 144 + 2 x $15/ft x 144)	$12,960
• Extra design and management time ($100/hr x 40hr)	$ 4,000
• Initial PRV testing (72 x 1.0hr x $100)	$ 7,200
• NFPA 25 costs for life of building (20 years)	
Qtrly Inspect (3 x 24 x .25hr x $100/hr x 20)	$36,000
Annual Test (72 x .5hr x $100/hr x 16)	$57,600
5-Year Full Flow (72 x 1.0hr x $100 x 4)	$28,800
PRV repair costs (72 x 5% x $940 x 20)	$67,680
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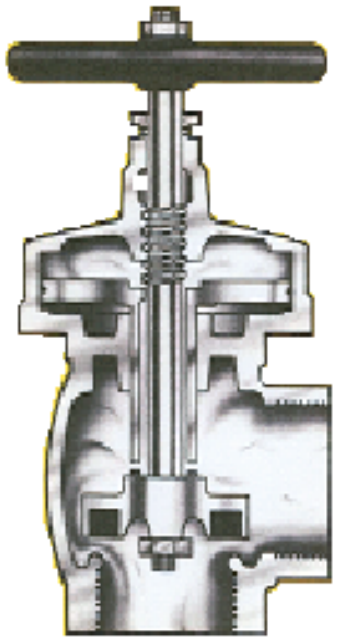
	$277,936

Note: Average annual testing cost is $12,888.
Note: Most of this testing is done on overtime, but this is not included.

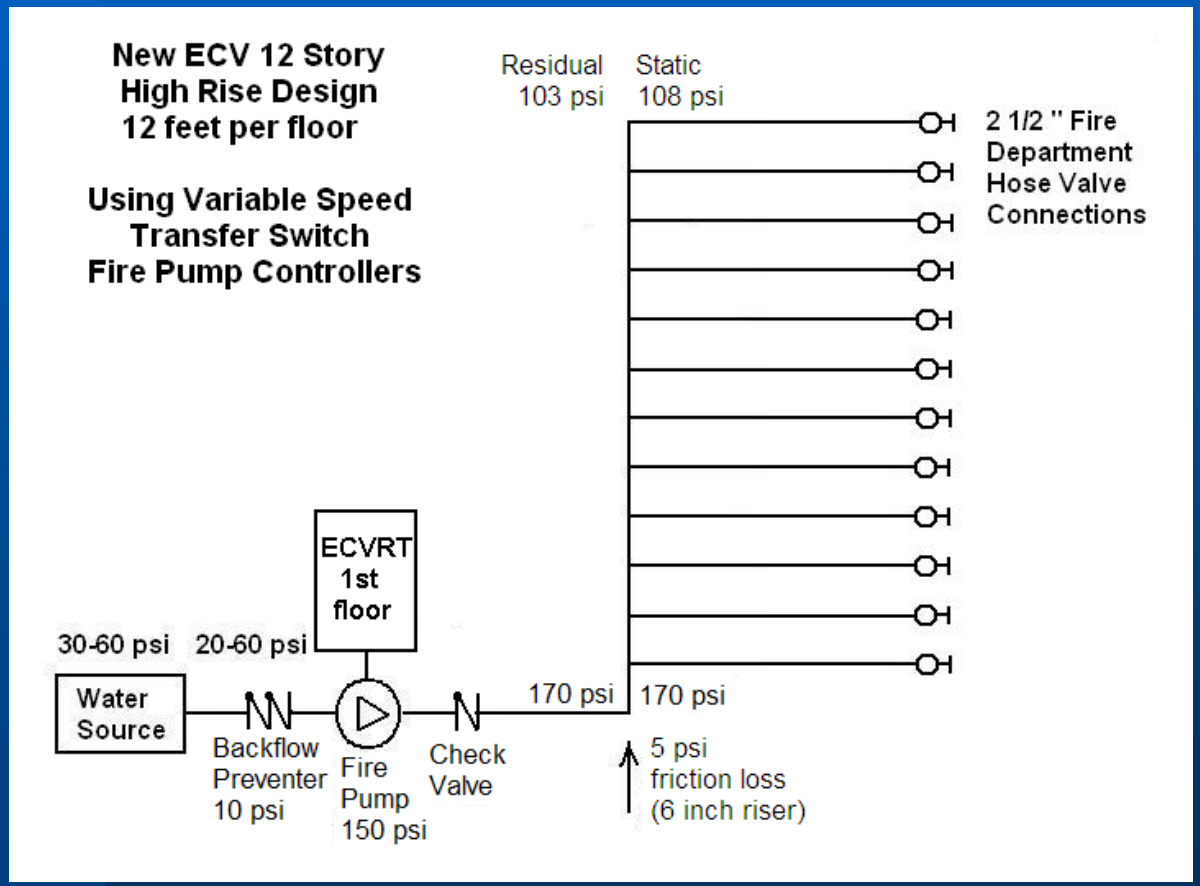
Conventional Design Problems



Typical PRV

- PRV's are always closed under normal conditions and must open when a fire occurs.
- They must be inspected quarterly and tested annually in accordance with NFPA 25.
- Most use non-adjustable PRV's to reduce costs; however, each valve must be factory set for the exact location in the building and installed accordingly.
- High swings in suction pressure will still eliminate it's use. Check the static and residual curves to be sure.

New 12 Story ECV Solution – 144 feet



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

12 Story ECV Design - Owner Costs

- Variable Speed Upgrade (150 hp, 460 v) $62,900
- Bypass Relief Valve (6 inch) $ 6,000

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$68,900

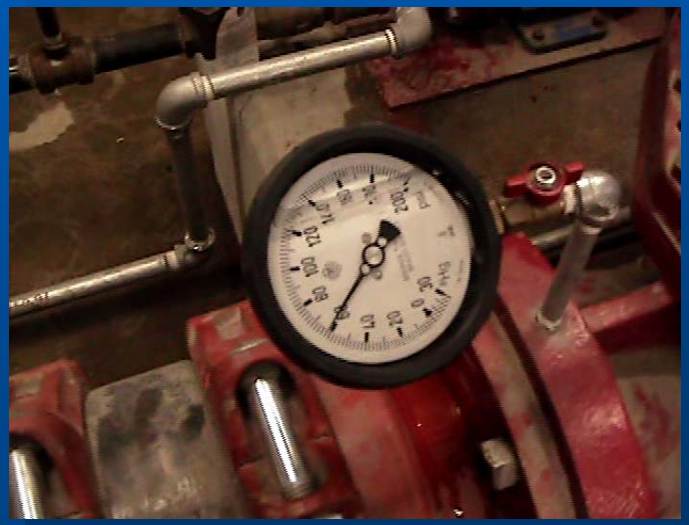
- Potential Gen-set savings ($300/kw*150 kw) $45,000

- Saves the owner $209,036 to $254,036 over the conventional design approach and eliminates PRV's!

ECV Job Videos

Starting with no flow

(Set Pressure = 175)



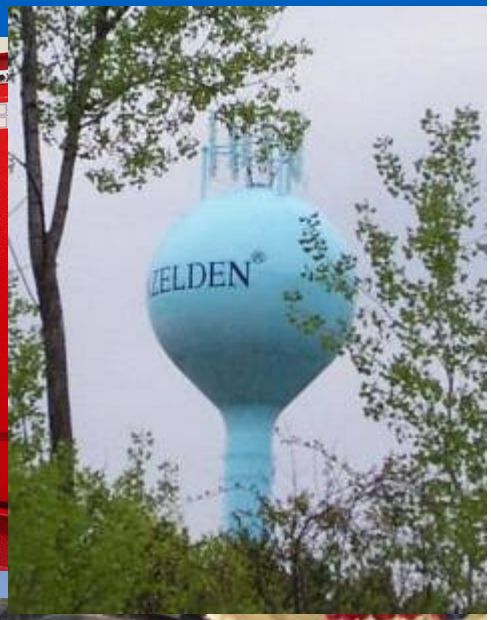
Starting with 3 hoses

(Set Pressure = 170)

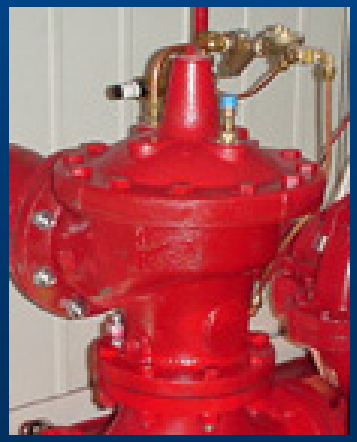
ECV Job Photos

ECV Photos – cont'd

ECV Photos – cont'd



Variable Speed Application Guidelines



- The motor should meet the NEMA design B, code G requirements and be suitable for inverter duty applications.
- The maximum pump horsepower should not exceed the motor nameplate horsepower. The service factor should not be used.
- A bypass relief valve is required to handle system overpressures that may occur when the manual operator is used or the VFD is bypassed.

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 typically 125-150% of the motor FLA while still producing 100% starting torque.
- The bypass starting current can be based on a voltage drop greater than 15% per NFPA 20-9.4.3

More about the Gen-Set

- Because the variable speed controller starts at low frequencies, the rated full load torque of the motor can always be supplied. This always allows the motor to accelerate to full speed, unlike wye-delta starting.
- NFPA 20 requires that the voltage drop shall not exceed 15% during starting or 5% during running. This typically requires the gen-set to be 2-3 times larger than normal.
- However, since the VFD is typically 125-150% of motor FLA, the gen-set may be smaller.

Gen-set Sizing Example

- Based on a typical application for a 150 hp motor utilizing soft starting, a gen-set manufacture's sizing program would select a 300 kW gen-set.
- For the same application, the program would select a 150 kW gen-set when using a variable frequency drive.
- This saves 150 kWs and cuts the gen-set size in half!
- But before we pocket this savings, let's check 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 is the same as with the VFD!
  - This is based on our ability to hold in at 65% voltage with a primary reactor bypass circuit so the gen-set can be sized for a 30% gen-set voltage dip during starting (see the 2010 version of NFPA 20, paragraph 9.4.3).
  - Note: typical soft starters are only rated for a minimum operating voltage of 85% of the nominal line so they can not take advantage of paragraph 9.4.3.

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 the drain riser required by NFPA 14.
- Requires fewer high pressure fittings.
- Allows smaller pipe sizes.
- Reduces the gen-set size.
- Reduces utility demand charges.
- Can design in a safety factor for future water supply changes.
- 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*