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

PUMPS FOR FIRE PROTECTION

MAINE BUILDING OFFICIALS INSPECTORS ASSOCIATION MBOIA FOUNDED IN 1972

Maine Fire Chiefs' Association

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INTRODUCTIONS

Michael Joanis, PE

- NFSA's Chief Engineer
- Responsible for delivery of technical services to our members
- University of Maryland, College Park
- Registered professional engineer
- NFPA 13 (discharge, hanging & bracing), 20, 200, 232, 241, 909/914
- NFSA Contractors and Manufacturers Councils
- Engineering & Standards, Quality Assurance, UL/FM Committees
- 28 years of experience as a sprinkler contractor and consulting engineer.
- Licensed sprinkler & special hazards contractor
- Fire Sprinkler Institute
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Fire Pump Systems

1. Introduction and purpose of fire pumps
2. Types of pumps
3. Suction piping arrangements
4. Equipment in suction pipe
5. Equipment in discharge pipe
6. Pumps in parallel and in series
7. Controllers and sensing line arrangement
8. Hydraulic formulas
9. Pump Sizing
10. Acceptance testing of a fire pump

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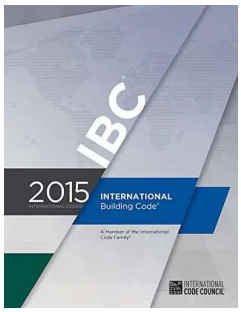
The Building Code

- Start in the applicable building code.
- Does provide some installation requirements.
- Supersedes NFPA 20.
- High rise Section 403.4.8
- Fire pumps Section 905 & 913



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The Installation Standard

- All sections referenced in this program are from the 2022 edition of NFPA 20 unless otherwise noted
- These are installation rules and have been in all recent editions unless otherwise noted
- Review Scope

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1. Purpose of Fire Pumps

- When the water supply can provide sufficient flow, but does not have the pressure to meet the demand of the fire protection system, pump can be used
- Pumps will not increase flow

= X gpm OUT
= Y psi + added pump pressure OUT

X gpm IN
Y psi IN

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Use of Pumps

- Boosting the pressure from a private or public water main
- Taking suction from a tank
  - Tank at the same level as the pump
  - Tank elevated above the pump
  - Pressure tank

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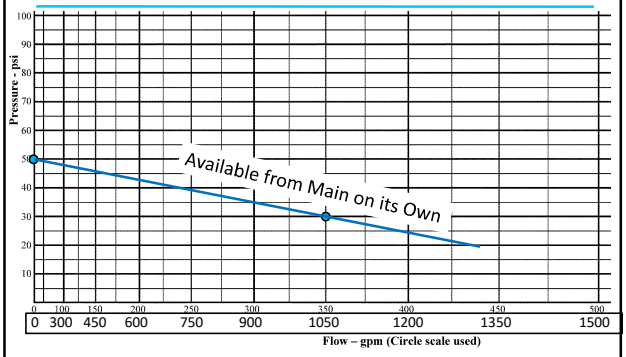
Public or Private Main



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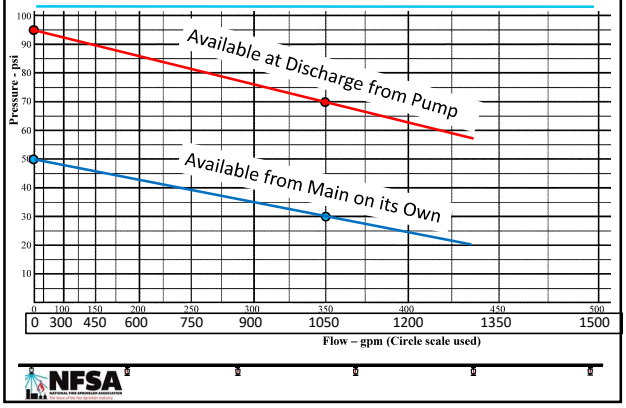
Main Plus Pump



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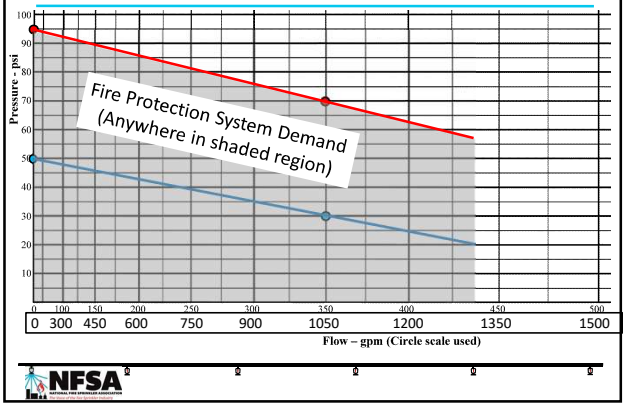
Main Plus Pump



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2. Types of Pumps

- Positive Displacement Pumps
  - Piston & Rotary Gear
  - Can pump air (priming pump on FD apparatus)
  - Very accurate
  - Can generate very high pressures
    - Water mist
  - Very good at pumping viscous liquids
- Centrifugal Pump
  - End Suction Pump
  - Horizontal Split Case Pump
  - In-Line Pump
  - Vertical (Line) Shaft Turbine Pump
  - Must have positive suction pressure

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How a Centrifugal Pump Works

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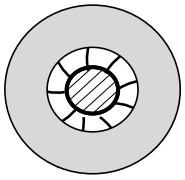
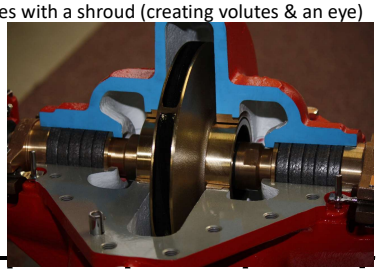
The Pump Impeller

- Start with a ring
- Set it on a drive shaft
- Attach some vanes
- Cover it on both sides with a shroud (creating volutes & an eye)





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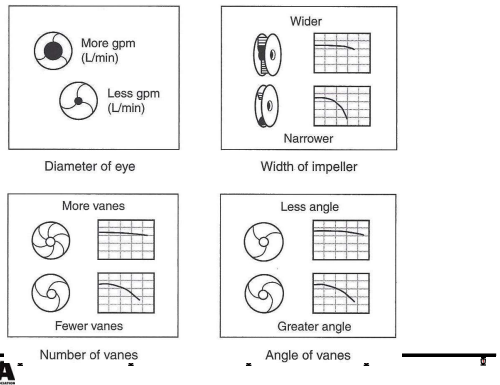
Impact on Performance



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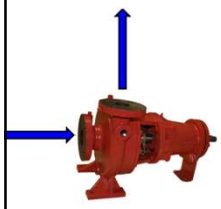
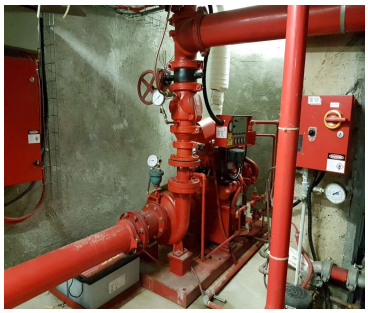
End Suction Pump





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Horizontal Split Case Pump

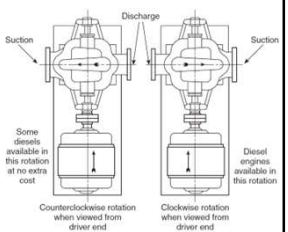

FIGURE A.4.23(a) Horizontal Pump Shaft Rotation.

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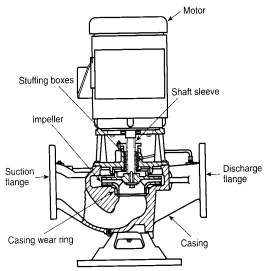
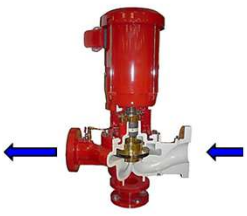
Vertical In-Line Pump





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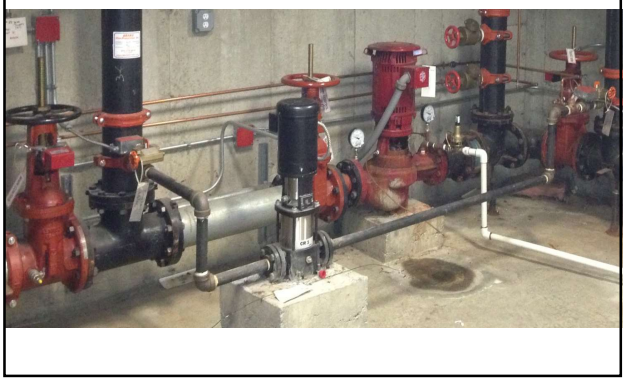

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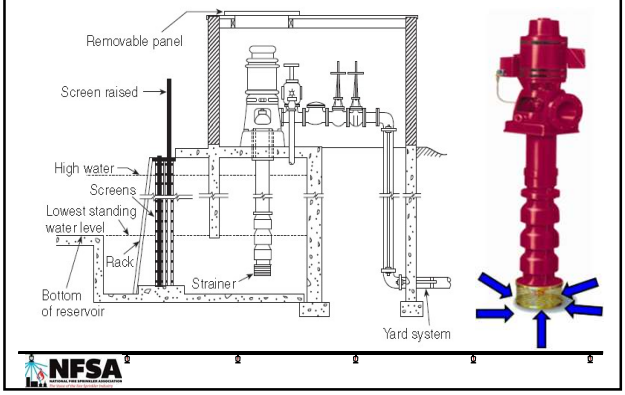
Vertical Shaft Turbine Pump



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Pump Room Requirements

- Location & access to
  - Approved by the AHJ
  - Free of non essential items
    - Exception for domestic water equipment
  - Direct or rated access to the exterior
- Size & clearances
- Protection (rated room)of the fire pump unit- indoors
  - Hi rise building
  - Non hi- rise building
- Protection of the fire pump unit- outdoors

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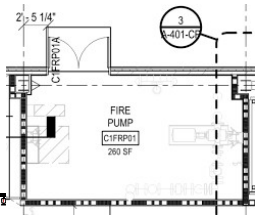
Pump Room Requirements cont

- Heat
- Lighting
  - Normal
  - Emergency
- Ventilation
- Drainage
- Guards



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General Rules for All Pumps

- Means must be provided for qualified personnel to determine the pump is operating satisfactorily
- The fire pump unit (pump, motor & controller) must perform as an entire unit
- Water supply must be reliable
- Pump must be dedicated to fire service & listed for such
  - Each pump shall have its own motor, & each motor its own controller, and each controller its own sensing line
- Must not be able to over pressurize the system components

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General Rules for All Pumps cont

- Each pump must have its own name plate
- Each pump must have suction & discharge gauges
- Each pump shall have a circulation relief valve (except where permitted to eliminate this requirement)
- Indoor units must be protected from surrounding occupancies
- Outdoor units must be protected against possible interruption
- Steel pipe must be used above ground

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General Rules for All Pumps cont

- Pump must have a positive suction pressure (≥ 0psi)
  - Exception for tanks
- Valves must be supervised
- All pumps part of a series unit shall be in the same pump room
  - Some exceptions with strict conditions
- No more than three pumps allowed in series as part of a series fire pump unit
  - Reduced to two for variable speed pumps

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General Rules for All Pumps cont

- Pumps must have means of testing
- Means of maintaining pressure in the system for pressure activated fire pumps without using the main fire pump
- Earthquake protection applies to the fire pump unit

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3. Suction Pipe Arrangement

- Straight run to suction flange
- Vertical bend (elbow or tee) into suction flange
- Horizontal bend (elbow or tee) into suction flange

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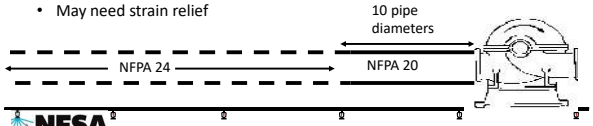
The Suction Pipe

- Starts at the pump suction flange
- Continues back to the water source
- NFPA 24 governs the suction piping
- NFPA 20 takes over at 10 pipe diameters before the suction flange

- Water Supply must be adequate in
  - Quality
  - Quantity
  - Pressure
  - May need strain relief



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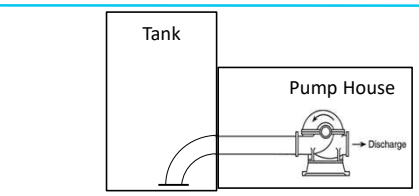
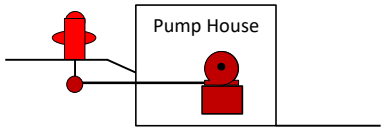
Straight Run to Suction Flange





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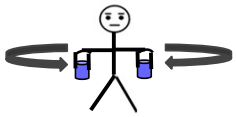
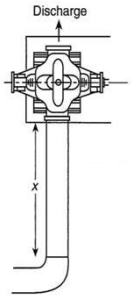
Horizontal Bend into Suction Flange

- Plan View of Horizontal Split Case Pump
- Only permitted if X≥10 times pipe diameter





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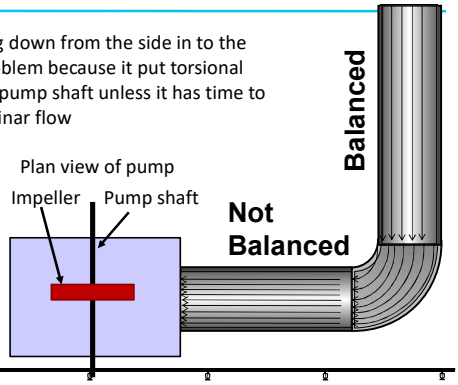
Balanced & Unbalanced Flow

Water coming down from the side in to the pump is a problem because it put torsional stress on the pump shaft unless it has time to return to laminar flow



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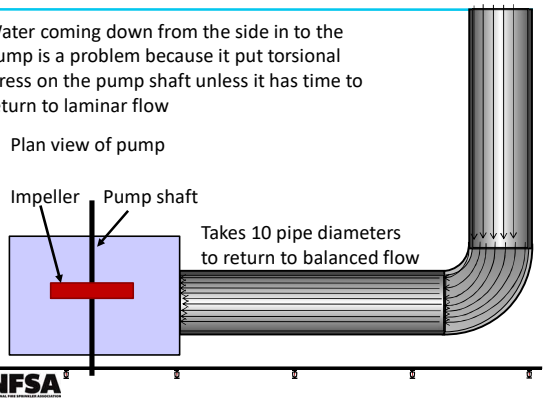
Balanced & Unbalanced Flow

Water coming down from the side in to the pump is a problem because it put torsional stress on the pump shaft unless it has time to return to laminar flow



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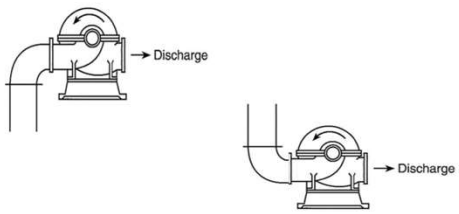
Vertical Bend into Suction Flange

Note: All required valves are not shown



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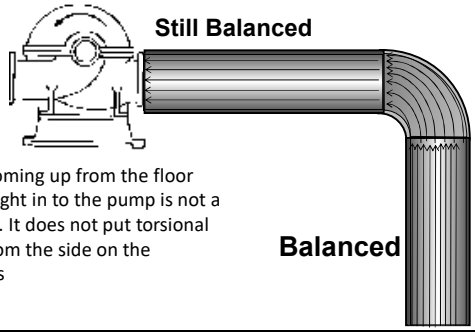
Balanced & Unbalanced Flow



Water coming up from the floor and straight in to the pump is not a problem. It does not put torsional stress from the side on the impellers

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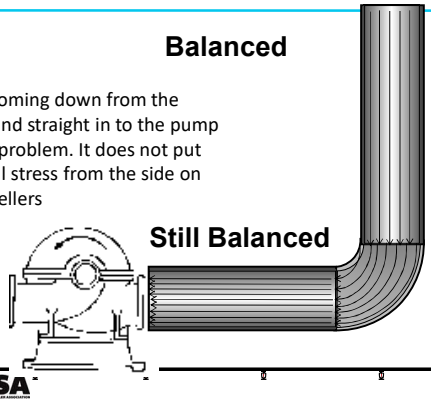
Balanced & Unbalanced Flow



Water coming down from the ceiling and straight in to the pump is not a problem. It does not put torsional stress from the side on the impellers

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Figure A.4.16.6

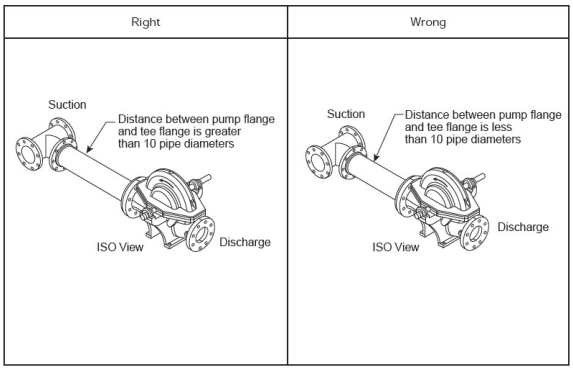

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Figure A.4.16.6

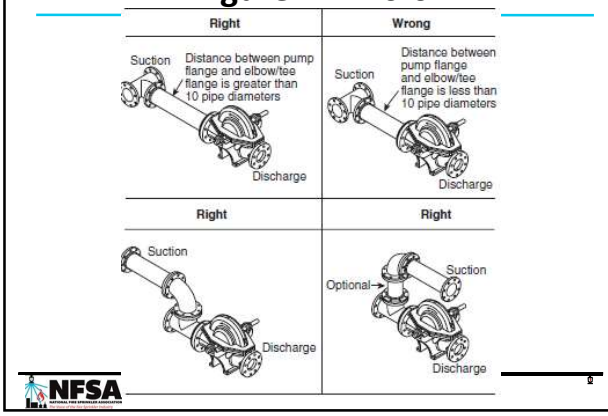

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Figure A.4.16.6

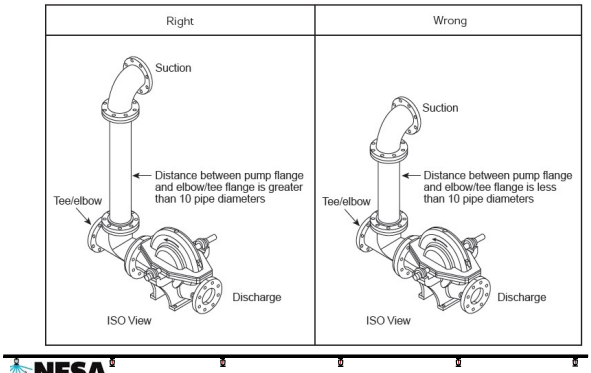

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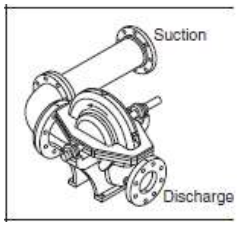
Figure A.4.16.6

Right or wrong?



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4. Equipment in Suction Pipe

- Design and installation in accordance with NFPA 24
- Must avoid air pockets

- Control valves, check valves and backflow
- Join pipe well to avoid water and air leaks (for bell & spigot joints)
  - Hydrostatic test will prove
- Reducers must be eccentric
- Protect pipe from freezing
- Screens (Open Water Source)

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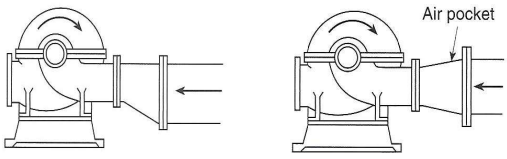
Reducers



Correct
Eccentric Reducer

Not Correct
Concentric Reducer

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Devices in Suction Pipe

- Control Valves
  - Need one to isolate the pump
  - Don't add extras
  - Gate not butterfly
  - Slow close
- Check Valves and Backflow Preventers
  - Cause turbulence, which can damage pumps
  - Keep at least 10 times the pipe diameter away from the suction flange of the pump

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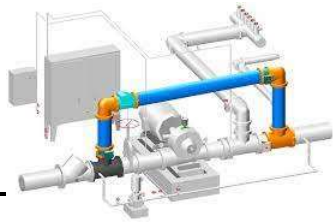
Devices Required in the Suction Piping

1. Bypass piping if water supply has material value
2. Listed OS&Y valve
   1. Any other type must be 50' away
3. Suction screening required if open body of water or wet pit
   a) Required size & number



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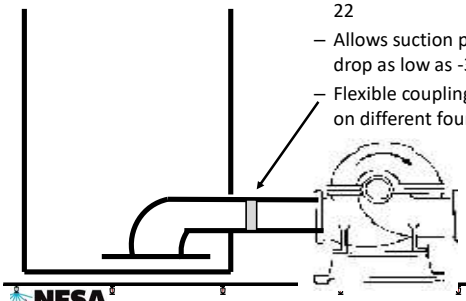
Devices Required in the Suction Piping cont

- Anti Vortex plate
  - Must be installed by NFPA 22
  - Allows suction pressure to drop as low as -3psi
  - Flexible coupling required if on different foundations



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Anti Vortex Plate

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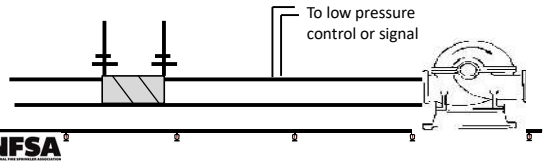
Devices Allowed in the Suction Piping

1. Check valves & back flow devices where required (must be 10 pipe diameters away)
2. Sensing line for low pressure control or signal
   a) Just the sensing line- no requirement for 10 pipe diameters
3. Other devices specifically permitted or required by the AHJ
4. Suction diffusers
5. Section 4.16.9.2



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5. Equipment in Discharge Piping

- Piping must be steel
  - Rated for Maximum Working Pressure
- Maximum Working Pressure = Static Pressure + (Net) Churn Pressure

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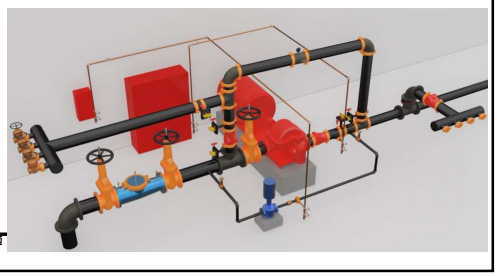
The Discharge Pipe

- Starts at the pump discharge flange
- Continues to the discharge control valve
- Must be sized according to Table 4.28(a)
- No pressure reducing valves allowed in discharge piping



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Devices in Discharge Piping

- Check valve and control valve
- Pressure Relief Valve (Section 4.20)
  - Only required if discharge pressure when turning 10% too fast exceeds component's rating
  - Under normal conditions, not needed
- Circulating Relief Valve
  - Required for electric driven pumps
  - Required for diesel driven pumps with radiator cooling

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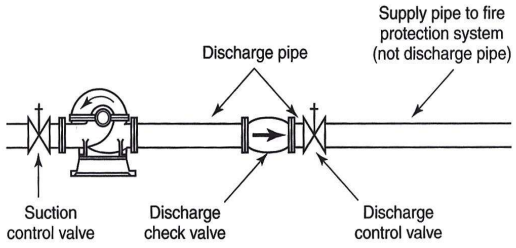
Discharge Pipe and Components



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Fire Pump Pressure Relief Valve

Pressure Relief Valve

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Fire Pump Circulation Relief Valve

Circulation relief valve

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Testing Arrangements

- Test Header to Open
- Flow to Reservoir
- Closed Loop Metering

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Test Headers

- Listed
- Number and size of outlets
- Location
- Shut-off Valve
- Drain
- Pipe Size (Table 4.28(a) or hydraulic calculations)

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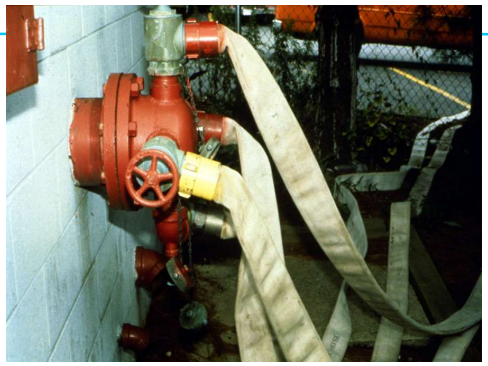

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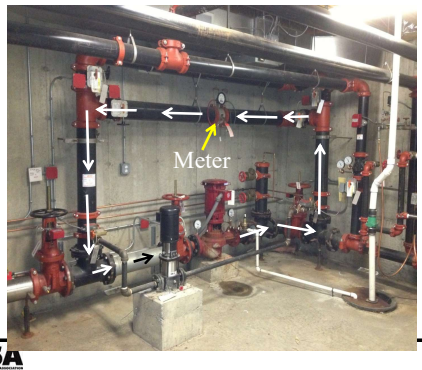
Closed Loop Metering



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Determining Flow

- Pitot Gauge
- "Pitotless" Gauge

- Flow Meter
  - Listed
  - 175% of Rated Flow
  - Size - Table 4-28(a)

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Pitot Gauge

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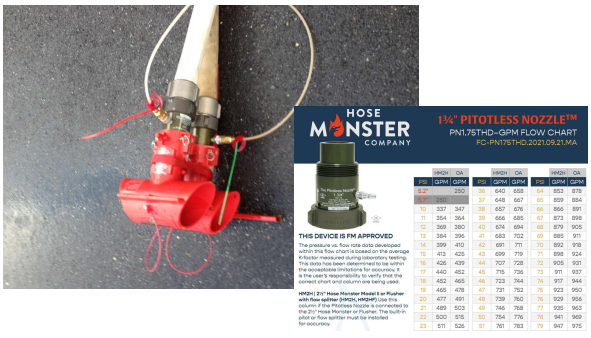
"Pitotless" Gage



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6. Pumps in Parallel and Series

- Pumps in Parallel
  - Multiple pumps in the same system where the water only goes through one pump on the way to the fire protection devices
- Pumps in Series
  - Multiple pumps in the same system where the water goes through one pump and then into another pump before going to the fire protection devices

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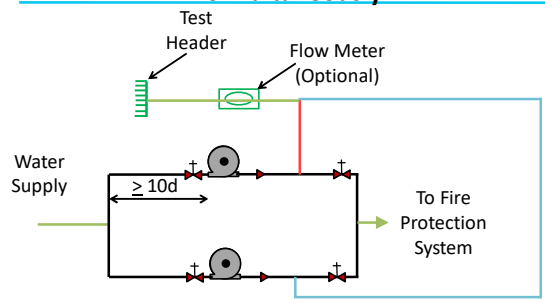
Testing Pumps in Parallel Designed to Operate Simultaneously



Piping to meter and test header needs to be sized for full flow of both pumps operating at the same time.

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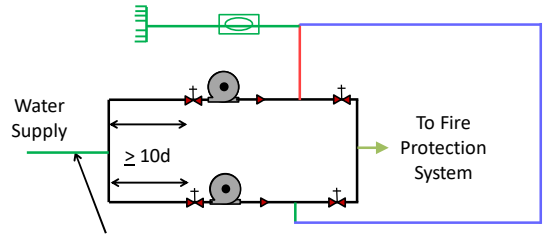
Pumps in Parallel Designed to Operate Simultaneously



Piping to multiple pumps needs to be sized for full flow of both pumps operating at the same time

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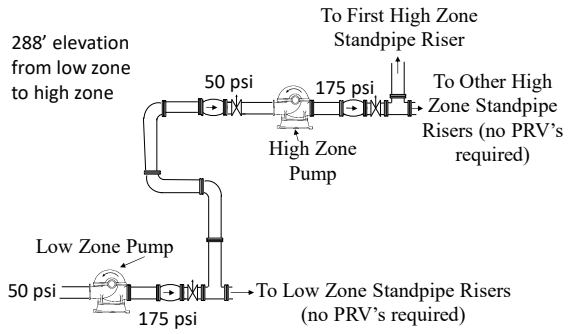
Pumps in Series

- Where high pressure can't be obtained by a single pump
- Where the building is divided into multiple vertical zones to control pressure
- Note: in the 2019 edition of NFPA 20, changes were made to allow multiple stage, multiple port pumps, which can substitute for pumps in series, but are beyond the scope of this class

66

Control System Pressure at Lower Floors



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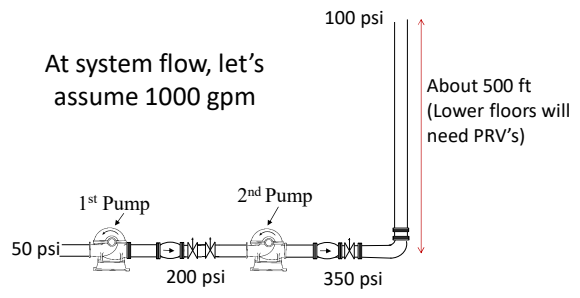
Meeting a High Demand Pressure



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7. Controllers and Sensing Lines

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Controllers

- "Brains" of the fire pump installation
- Monitor the conditions within the fire protection system
- Monitor the fire pump and its associated equipment
- Start the pump when needed
- Let people know what is happening

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Controllers

- Controllers have to be listed for fire pump service
- Every fire pump needs its own controller
- Every jockey pump needs its own controller

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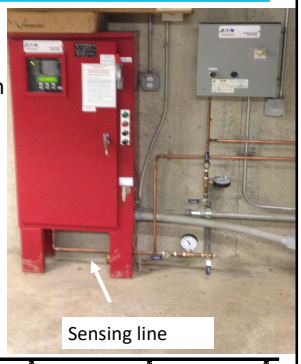
Sensing Lines

- Pipe that goes between controller and system
- Connected to system between discharge check valve and control valve
- Separate for each pump
- Minimum 1/2" corrosion resistant pipe
- Check valves/Ground Face Unions



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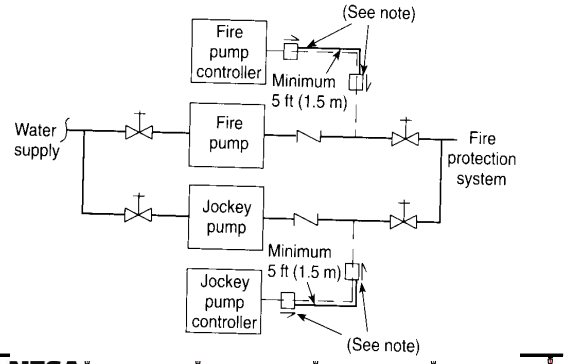
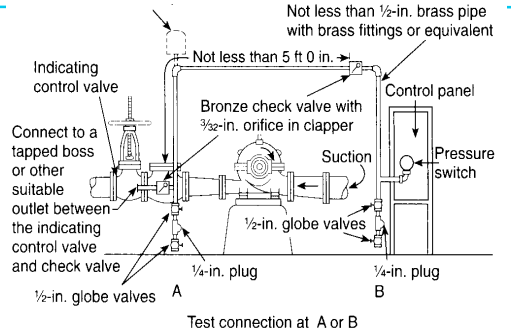
Pressure Sensing Line Connections



73



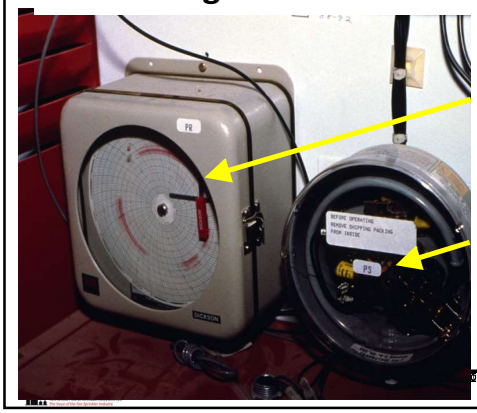
74

Pressure Recorder

- Required on the sensing line to all controllers
  - May be inside the controller
  - May be outside the controller on the sensing line
- Records pressure in fire protection system over 7 day period
- Analog or digital

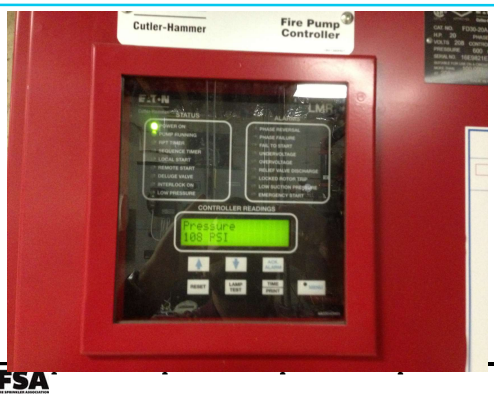
75

Analog Pressure Recorder



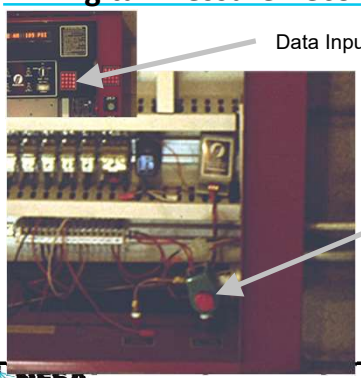
76

Digital Pressure Recorder/Switch



77

Digital Pressure Recorder/Switch



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Starting the Pump

- Automatic & Manual
- Programmed Timer (Weekly Testing)

- Diesels Pumps Started By:
  - Batteries
    - 2 Sets
    - 15 Second Intervals
  - Hydraulic start
  - Air pressure start

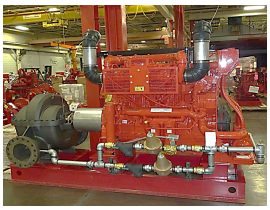
79

Stopping the Pump

- Manual - Main Switch and Stop Button
- Automatic - only allowed when all starting conditions have returned to normal
- Automatic Shutdown for Electric Motors only under two conditions
  - AHJ permits automatic shutdown
  - Automated testing meeting 5 parts of 10.5.2.7
- Automatic Shutdown for Diesel Engines only under three conditions
  - AHJ permits automatic shutdown
  - Overspeed condition occurs
  - Automated testing meeting 7 parts of 12.7.2.7

80

Controllers for Diesel Engine Driven Pumps



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Diesel Engine Controllers

- Listed for diesel engines
- Within sight of engine
- Clearances - NFPA 70 Article 110
- Signage
- Grounding - NFPA 70 Article 250
- 1 per Pump

82

Alarms and Signals

- Alarms sent to a constantly attended location
  - Pump running
  - Controller has been turned to off or manual
  - Any of the other trouble signals

83

Mandatory Signals

- Visible indicator and common audible alarm
  - Critically Low Oil Pressure
  - High Engine Temperature
  - Failure of Automatic Start
  - Overspeed Shutdown
  - High Cooling Water Temperature

84

Mandatory Signals (cont)

- Visible indicator and common audible signal
  - Battery and Charger Failure
  - Low Air or Hydraulic Pressure (only if these starting mechanisms are present)
  - System Overpressure (variable speed drivers only)
  - For ECM Control Engines
    - Selector switch in alternate ECM position
    - Fuel injection malfunction

85

Battery Condition Monitoring on Controller

86

ECM Control Panel on Engine

87

Mandatory Signals (cont)

- Visible indicator and common audible signal
  - Low fuel level (less than 2/3 of a tank)
  - Low engine temperature
  - Liquid into interstitial space of double-wall tank
  - High cooling water temperature
  - Fuel maintenance required for those systems with fuel maintenance systems

88

Recommended Signals

- Low Pump Room Temperature
- Relief Valve Discharge
- Flow Meter bypass “on”
- Water Level or Pressure in Suction Pipe

89

Controller Panel

90

Signals

- Signal at the controller
- If the pump room is not a constantly attended location, send the signals to a constantly attended location

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Controllers for Electric Motor Driven Pumps

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Power for Fire Pumps- Electric

- Electric Motors & Controllers
  - All equipment must be installed according to NFPA 70
    - No phase converters
  - Provided with normal power from a continual source
    - Alternate power is required
      - High rise buildings
      - Where building height is beyond pumping capacity of the fire department
      - Where normal power is not reliable (A.9.3.2)
    - Must have an alternate power source if normal power is not reliable

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Power for Fire Pumps- Electric cont

- Electric Motors cont
  - Must be listed for fire pump service
  - Motors with variable speed controllers must meet requirements of NEMA MG-1 & listed
  - Specific rules for generators used as standby power sources

94

Power for Fire Pumps- Electric cont

- Electric motor controllers
  - Must be listed for electric motor driven fire pumps
  - Must be within sight of the motor they control
  - Specific signal devices on the controller
    - Power available
    - Phase reversal
  - Specific signals remote from controller to a constantly attended location if pump room is not constantly attended
    - Pump or motor running
    - Loss of phase or phase reversal
    - Controller connected to alternate power

95

Power for Fire Pumps- Electric cont

- Electric motor controllers cont
  - Must be capable of starting both automatically & manually
  - Special rules for controllers in excess of 600V
  - Special rules for limited service controllers
    - ≤ 30hp, ≤ 600V, across the line starting
  - Separate rules for power transfer to alternate power
  - Specific rules for variable speed controllers

96

Power Supply Arrangements

- Power arrives at proper voltage; or
- Transformer installed to change voltage
  - Step-up Transformer increases voltage if supply is too low
  - Step-down Transformer decreases voltage if supply is too high

97

Isolating Switch & Breaker

- Isolation switch
  - Operable from outside the controller
  - Warning Label or Circuit Breaker Interlock

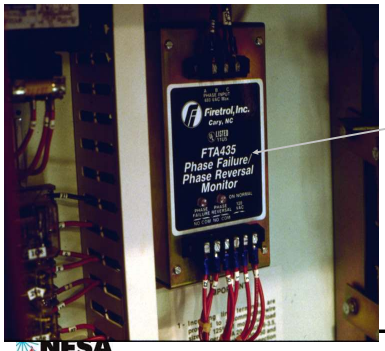
- Circuit breaker
  - Operable from Outside Controller
  - Labeled

98

Signals

- Required signals
  - Power available
    - Individual phases
    - From all power sources
  - Phase reversal
- Required to sound at constantly attended location
  - Pump Running
  - Loss of Phase
  - Phase Reversal

99



Phase Reversal Monitor

- Inside Controller
- "On" is normal

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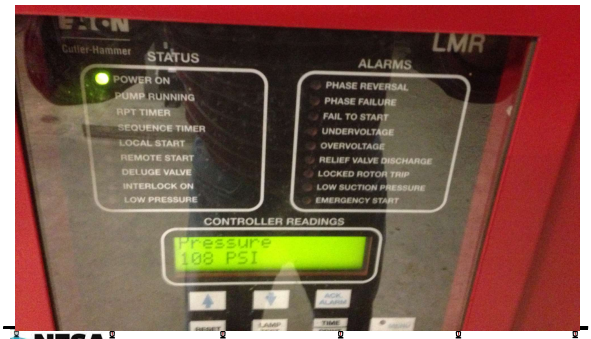
Indicators on Outside of Controller



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Transfer Switches

- A listed device
- Used when two power supplies
- Physically connects the controller to the main power supply unless power is lost, low voltage or phase reversal
- If activated, disconnects from the main power supply and connects the controller to the secondary supply

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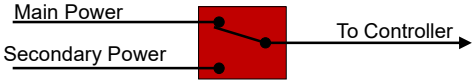
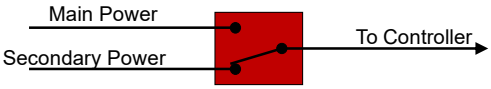
Transfer Switch

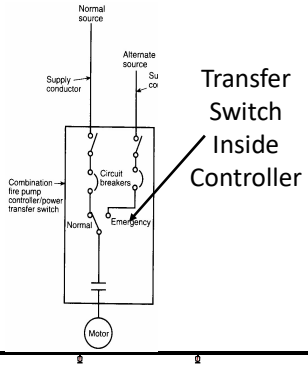


Transfer Switch Connected to Main Power Supply



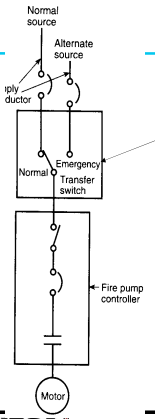
Transfer Switch Connected to Secondary Power Supply

103



Transfer Switch Inside Controller

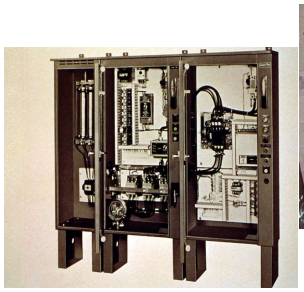
104



Transfer Switch Outside of Controller

105

Transfer Switch Outside Controller



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8. Hydraulic Formulas

- Elevation Pressure Change
  - 0.433 x change in height (in feet)
  - Loss of energy going uphill
  - Gain of energy going downhill
- Friction Loss with Hazen-Williams formula
  - $P_f = \frac{4.52(Q)^{1.85}}{(C)^{1.85}d^{4.87}}$
  - $P_{fl} = P_f(L)$

P_f = Friction loss per ft of pipe
Q = flow in pipe in gpm
C = relative roughness of pipe
d = inside diameter of pipe
P_{fl} = Total friction loss in pipe
L = length of pipe

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Pump Formulas

- Net Pressure formula: $P_N = P_D - P_S$
- Discharge Pressure formula: $P_D = P_S + P_N$
- P_N = The net pressure produced by the pump
- P_D = Pressure at the pump's discharge
- P_S = Pressure at the pump's suction
- Each of these pressures changes as the flow changes

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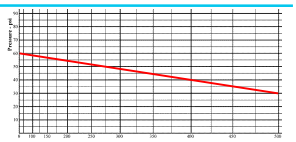
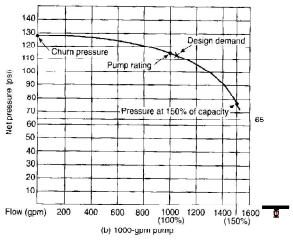
Pump Pressures

- Suction Pressure – function of the water supply
- Net Pressure – function of the pump
- Discharge Pressure – function of water supply and pump





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Terminology

- Water Supply
  - P_{Static} = Static Pressure = pressure from the water supply when there is no water flowing in the fire protection system
  - $P_{Residual}$ = Residual Pressure = pressure from the water supply when a specific flow is going into the fire protection system
- Pump
  - Churn – when the pump is running but no flow is going into the fire protection system
  - Rated Flow – the flow at which the pump is rated
  - Maximum Flow – 150% of the rated flow (there is an exception, but it is beyond the scope of this class)

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Suction Pressure

- $P_S = P_{Residual} - P_E - P_{fl}$
- This calculation needs to be done at several flows
  - At the flow demand for the fire protection system to make sure that the discharge pressure can meet the pressure demand
  - At maximum flow to make sure that the suction pressure is positive
  - At churn to make sure that the discharge pressure does not over-pressurize the system (note that at this flow, the Residual Pressure is the Static Pressure)

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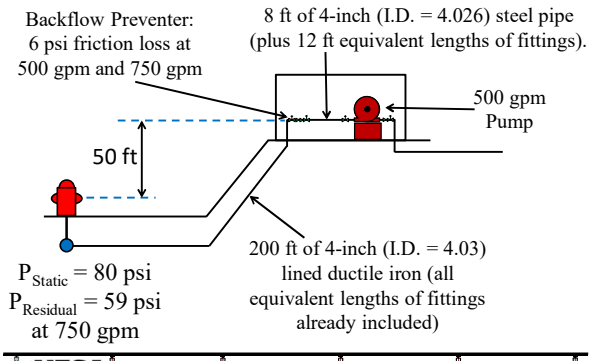
Example



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9. Pump Sizing

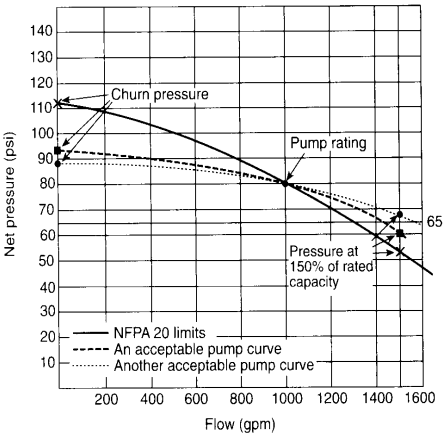
- Rated Flow (25-5000 gpm)
- Rated Pressure (40-200 net psi)
- Rated Speed

113

Permissible Performance Ranges

- Allows *maximum* 140% rated net pressure at churn (no flow)
- Requires a *minimum* of 65% rated net pressure at 150% of rated flow (max. flow)

114



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Pump Sizing – 7 Step Procedure

1. Calculate system demand to pump discharge flange
2. Calculate suction pressure
3. Select pump so that the system flow demand is less than 150% (annex recommends 90-140%) of the rated flow of the pump. Section 4.10.
4. Using the Manufacturer's Pump Curve, find the pump's net pressure at the system demand flow

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Pump Sizing – 7 Step Procedure

5. Add the suction pressure to the net pressure to get the discharge pressure (all at demand flow)
6. If the discharge pressure is greater than the demand, okay. If not, select new pump.
7. Check maximum pressure produced by pump and make sure that the pump does not create more pressure than the equipment can handle

117

10. Acceptance Testing of Fire Pumps

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Acceptance Test Forms

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NFPA Annex Form – A.14.1.3

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Before the Testing Safety Concerns

- Survey the site, where will all the water go?
- Will your ears need protection?
- Will your eyes need protection?
- Will you need arc flash PPE?

120

Before the Testing

- Annually calibrate gauges, transducers and other devices used for measurement
  - Accuracy level of ± 1%
  - Factory calibrated voltage and current readings on controllers that are accurate to ±2% are permitted to be used instead of volt/ohm meters
- Visually inspect flow devices, discharge and sensing orifices to make sure they are free from damage and obstructions (not required to disassemble)
- If diesel engine with dry batteries, add electrolyte at least 24 hours before test and fully charge

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Test Requirements

Chapter 14 of NFPA 20

- 14.1 Hydrostatic Tests & Flushing
- 14.2 Field Acceptance Tests
- 14.3 Record Drawings, Manuals, Special Tools and Spare Parts
- 14.4 ITM
- 14.5 Component Replacement

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Flushing the Suction Pipe

- Flushing needs to be done prior to hydrostatic test
- Flow for flushing
  - Flow in table on next slide
  - Hydraulically calculated water demand if it is greater than the flow rate on the next slide
  - If the water supply can't provide either of the above, flow the larger of:
    - Fire protection system demand
    - Rated flow of the pump

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Flush Test

- Flow is calculated to produce a velocity of 15 ft/sec
- This is greater than the other NFPA standards that use 10 ft/sec

Nominal Pipe Size (in.)	Flow Rate (gpm)
3	330
4	590
5	920
6	1360
8	2350
10	3670
12	5290

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Hydrostatic Test

- Must be done before field test
- Test suction and discharge piping
- Pressure for test, higher of
  - 200 psi
  - 50 psi + maximum system pressure

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Before the Field Acceptance Tests

- Make sure all of the people that need to be there are assembled
  - Pump Manufacturer or their Rep.
  - Engine (if used) Manufacturer or their Rep.
  - Controller Manufacturer or their Rep.
  - Transfer Switch (if used) Manufacturer or their Rep.
  - Coordinate with all AHJ's
  - What about installing contractor, motor manufacturer, insurance company, and building owner?
- All electrical wiring must be completed (including jockey pump)
- Have a copy of the manufacturer's certified shop curve for the pump

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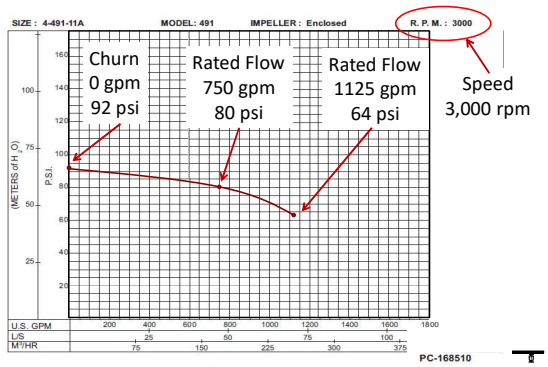
Manufacturer's Certified Performance Curve



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Pump Information

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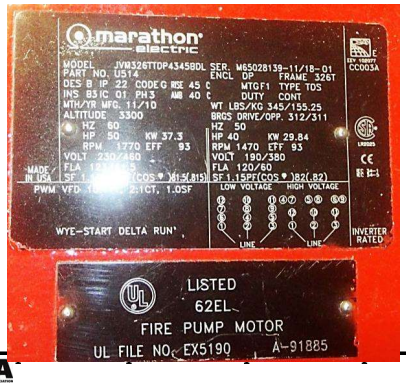
Driver Information



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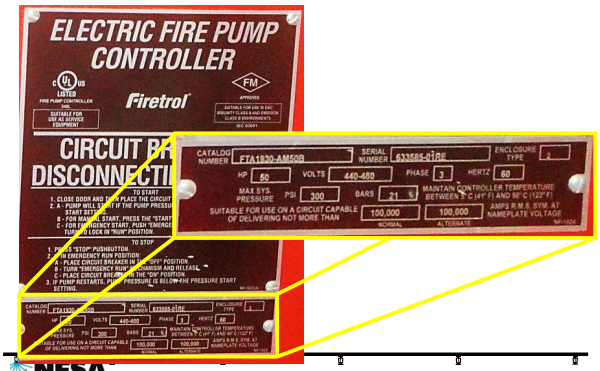
Controller Information



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Field Acceptance Tests

- Pump Performance
- Drivers and Right Angle Gear Drives
- Controller Performance
  - Controllers for Electric Motor Driven Pumps
  - Controllers for Diesel Driven Pumps
- Transfer Switch and Alternate Power Supply
- Break Tank Refill (if break tank installed)
- Water Level Detection for Vertical Shaft Turbines

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Additional Tests

- Beyond the scope of this class
  - Variable speed pumps
  - Multi-stage multi-port pumps
  - Positive displacement pumps

132

Pump Performance Test

- Flow Test at Minimum, Rated, and Peak Flow
  - Measured by Discharging Water or by Flow Meter
  - Need to match certified curve within accuracy of test equipment

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Pump Performance Test

- Flow Conditions
  - Churn
  - Rated Flow
  - Peak Flow (150% of rated flow or the maximum flow available from the water supply)
- Pressure Readings
  - Discharge Pressure
  - Suction Pressure
  - Calculate Net Pressure from above

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Measuring Flow

- If using a Pitot Gauge
  - $Q = 29.83cd^2\sqrt{P_{Pitot}}$
  - Q = flow in gpm
  - c = nozzle coefficient (0.97 for most straight open nozzles)
  - d = nozzle outlet diameter in inches
  - P = Pitot pressure in psi
- If using a flow meter, a control valve will allow specific flow conditions to be achieved

135

Test Procedure

1. Water at test header (priming the pump and getting all air out of the system)
2. Start the pump
3. General pump operation
   - No unusual vibrations, noises, oil or water leaks
   - If circulating relief valve is present, did it open?
4. Check packing gland (adjust if needed)
5. At churn (no flow into system), record:
   - Suction Pressure, Discharge Pressure, RPM
   - Amperes & Volts (if applicable)

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Field Acceptance Test

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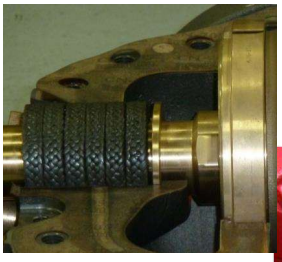
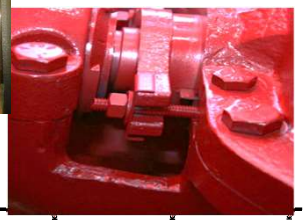
Packing Gland Adjustment





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Test Procedure

6. Open test header valves or flow meter control valve to achieve 100% of rated flow

7. At rated flow, record:
   - Suction Pressure, Discharge Pressure, RPM
   - Pitot Gage Readings or Flow
   - Amperes & Volts (if applicable)

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Pitot Tube

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Outlet Meters

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Flow Meter

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Test Procedure

8. Open test header valves or flow meter control valve to achieve 150% of rated flow
9. Record data at 150% of rated flow
10. Calculate pump net pressures
11. Plot flow curve
12. Compare flow curve to manufacturers shop curve
13. Plot ampere curve (electric motor)
14. Compare ampere curve to manufacturers curve

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Test Pump Speed

- Test results may need to be adjusted for variations in speed
- $P_{N1} = P_{N2}\left(\frac{S_1}{S_2}\right)^2$
- P_{N1} = Net pressure at speed condition 1
- P_{N2} = Net pressure at speed condition 2
- S_1 = Speed 1
- S_2 = Speed 2

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Water Level Detection for Vertical Shaft Turbines

- To get the suction pressure for vertical shaft turbine pumps, need to know the water level in the wet pit or sump
- Test at:
  - Churn (no-flow, or shutoff)
  - Rated Flow
  - Maximum Flow (Peak Flow)

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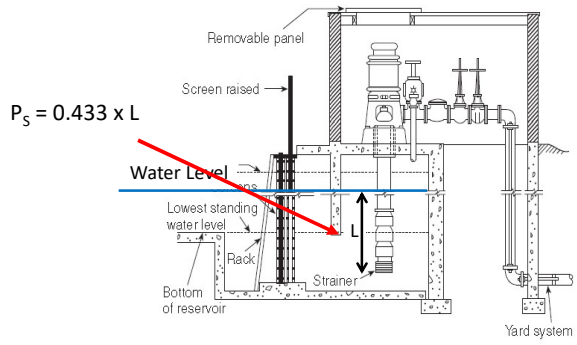
Vertical Shaft Turbine Pump



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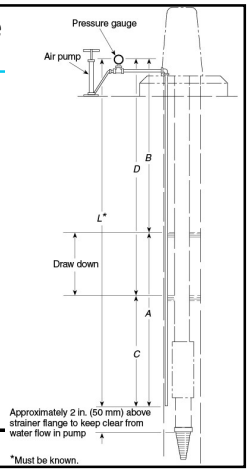
One Method to Determine Water Level

- See A.7.3.5.3 of NFPA 20 for how to use this tube and a simple bicycle pump to determine the water level



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Electric Motor

- If the motor operates at constant voltage and frequency, do the following on each phase
  - Multiply the full load amp rating times allowable service factor stamped on motor nameplate
  - Make sure the amp demand during the test did not exceed the number above
  - The voltage at the motor contactor does not vary more than 5% below or 10% above the voltage stamped on the nameplate

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Diesel Engines

- During flow test, make sure that engine does not show signs of overload or stress
- Set governor to regulate engine speed
  - Rated speed at maximum flow (150% of rated flow)
  - Allowed to speed up as much as 10% when flowing less water (including churn)

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Controller Acceptance Test

- 12 Starts
- 6 Automatic/6 Manual
  - Test each starting condition at least once
- Pump Runs 5 min @ Full Speed
  - Engines are not required to run for 5 minutes until the cumulative cranking time reaches 45 seconds
  - For engines, alternate the starts from different battery sets
- Check Overcurrent Devices

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Controller Acceptance Test

- Full Load Test
  - With discharge equal to full load, start the pump and make sure it comes up to full speed without interruption
- Phase Reversal Test (Electric Motor Driven Pumps)
  - While the pump is running make sure that phase reversal has not occurred
  - While the pump is running from the alternate power source, make sure phase reversal has not occurred

NFSA

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Transfer Switch Test

- With the pump running at maximum flow simulate power failure
- Transfer switch must sense loss of power and transfer to alternate power without tripping circuit breaker(s)
- Run half the manual and automatic starts from alternate power source
- Return normal power and see if the transfer switch reconnects to the normal source

NFSA

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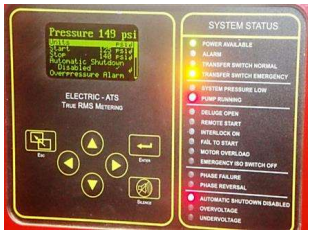
Signals and Indicators

- During all of the tests described here, all signals and indicators that should have occurred need to have occurred
- All other signals need to be simulated to make sure they operate properly



NFSA

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Controller Test

NFSA

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Pump Running Duration

- During all of the testing, the pump shall run for a total of at least one hour

NFSA

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Generator Test

- Installed and tested in accordance with NFPA 110

NFSA

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Break Tank

- Operate the refill device at least 5 times
  - Lower the water level in the tank
  - The automatic fill mechanism must operate before the water level drops more than 4 inches below the overflow outlet (see NFPA 22: 14.5.2.2.5)
- Test and record the refill rate
  - Must meet or exceed design refill rate

NFSA

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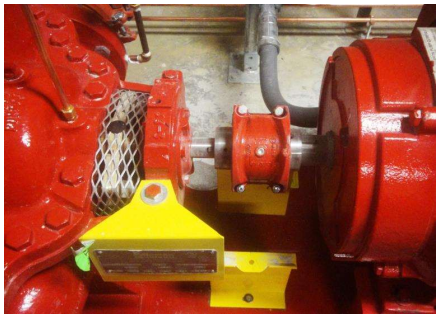
Section A.6.5 Recommends Alignment Test

- Angular Alignment
- Parallel Alignment



NFSA

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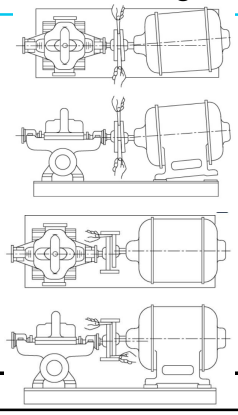
Section A.6.5 Recommends Alignment Test

- Angular Alignment
- Parallel Alignment



NFSA

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Pressure Switch Settings

- Jockey Pump
  - Start : normal system pressure - 10 psi
  - Stop : churn pressure + static supply
- Fire Pump
  - Start : jockey pump start pressure - 5 psi
  - Stop : churn pressure + static supply

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Information For Owner

- Operating Manuals
- Instructions for Routine Maintenance (NFPA 25)
- Parts List
- Electrical Schematics
- Manufacturers Certified Shop Curve

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CONCLUSION

Questions?

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