Selection, Testing and Performance of Fire Pumps in Buildings and Industrial Facilities

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Contents

- Definitions
- General Layout of Fire Pump House
- Selection and Addition Of Fire Pumps
- Acceptance & Performance of Fire Pumps
- Testing and Inspection Of Fire Pumps
Fire Pump Unit: An assembled unit consisting of a fire pump, driver, controller, and accessories.

Fire Pump: A pump that is a provider of liquid flow and pressure dedicated to fire protection.

Rated Flow: The capacity of the pump at rated speed and rated pressure as marked on the manufacturer's nameplate.

Pressure Maintenance (Jockey or Make-Up) Pump: A pump designed to maintain the pressure on the fire protection system(s) between preset limits when the system is not flowing water.

Discharge Pressure: The total pressure available at the fire pump discharge flange.

Rated Pressure: The net pressure (differential pressure) at rated flow and rated speed as marked on the manufacturer’s nameplate.
General Layout of Fire Pump House
1. OS&Y Gate Valve w/TS
2. Compound Suction Gauge
3. Horizontal Split Case Fire Pump
5. Casing Relief Valve
6. Discharge Pressure Gauge
7. Relief Valve if shutoff > 175 psig
8. Waste Cone (closed type)

9. Wafer Check Valve
10. Jockey Pump
11. Butterfly Valve w/TS
12. Test Header & hose valves
13. In-line Flow Meter & piping
14. Fire Pump Control Panel
15. Jockey Pump Control Panel
16. Jockey Pump Sensing Line
17. Fire Pump Sensing Line
18. Jockey Pump Suction
19. Jockey Pump Discharge
NFPA 20 recommends that pumps should run at 90% - 140% of rated capacity
Adding a Fire Pump to Calculations

- Calculations for a sprinkler system reveal that city water supply cannot support pressure demand
- Option 1: Increase system pipe sizes
- Option 2: Add a pump
- Always try increasing pipe sizes first
- Adding a pump is an expensive option
Calculating a sprinkler system you find demand is 510 GPM @ 42 PSI including a 250 GPM inside hose allowance. There is no city water supply & a lake is the water source. Vertical turbine pump is used due to lake’s lower elevation.

Determine if a 1760 RPM vertical turbine rated at 500 GPM @ 45 PSI is a suitable choice.

Pump has churn pressure of 50 PSI.
System demand point is below pump curve; pump will satisfy demand. Demand point is 3 PSI below pump curve; the next pump rated at 500 GPM @ 50 PSI, is a better choice.
Example 2

Start by plotting city water supply & system demand
Example 2

You can then plot pump curve on graph
System demand point falls below the combined curve which means pump is adequate
800 GPM at 160 feet of discharge head is required.
A copy of the manufacturer's certified pump test curve shall be available for comparison with the results of the field acceptance test.

The actual unadjusted fire pump discharge flows and pressures installed shall meet or exceed the fire protection system's demand.
Sample Centrifugal Fire Pump Acceptance Test Form

Information on this form covers the minimum requirements of NFPA 20 for performing acceptance tests on centrifugal fire pumps with electric motor or diesel engine drivers. A separate form is required for each pump operating simultaneously. This form does not cover periodic inspection, testing, and maintenance required by NFPA 20.

Owner:
Owner's address: ____________________________
Pump location: _______________________________
Property address: ____________________________

Date of test:

Maximum demand(s) of fire protection system(s) ___________ gpm at ___________ psi for ___________ minutes at fire pump discharge.
System demand information supplied by: ____________________________

Pump type: Horizontal □ Vertical □ Inline □ Other (specify) □
Manufacturer: ___________ Model or type: ___________
Shop/Serial number: ___________
Pump rated for: ___________ psi at ___________ RPM, not discharge pressure: ___________ psi at 150% ___________ psi at churn
Pump suction size: ___________ in., discharge size: ___________ in., suction from ___________
If suction from tank, tank diameter: ___________ ft, height: ___________ ft, capacity: ___________ gpm
Driver: Electric motor □ Diesel engine □ Steam turbine □
Manufacturer: ___________ Shop/Serial number: ___________
Rated horsepower: ___________ HP (or kW) □
If electric motor, rated voltage: ___________ Operating voltage: ___________
Rated rpm: ___________ Service factor: ___________
Controller manufacturer: ___________
Shop/Serial number: ___________
Controller rated: ___________ HP □ VAC □
Does controller rated HP & VAC match motor? □ Yes □ No
Transfer switch rated: ___________ HP □ VAC □
Does controller rated HP & VAC match switch? □ Yes □ No □ N/A
Pressure maintenance (jockey) pump on system? □ Yes □ No □ Manual □ Automatic
Manufacturer: ___________ Shop/Serial number: ___________
Model or type: ___________ □ Centrifugal or □ Positive displacement
Pressure relief valves provided on jockey pump discharge? □ Yes □ No □ N/A
Jockey pump rated for: ___________ gpm at ___________ psi at ___________ RPM □ HP □
Jockey pump suction size: ___________ in., discharge size: ___________ in.
Jockey pump controller manufacturer: ___________
Shop/Serial number: ___________
Jockey pump controller rated: ___________ HP □ VAC □
Does jockey pump controller rated HP & VAC match motor? □ Yes □ No

Note: All blanks are to be filled in. All questions are to be answered Yes, No, or Not Applicable. All "No" answers are to be explained in the comments portion of this form.

I. Flush Test (Table 14.1.1) — Before hydrostatic test:
A. Suction supply from ground level storage tank or reservoir ___________ □ Yes □ N/A
B. Suction piping was flushed at ___________ gpm? (See Table 14.1.1) ___________ □ Yes □ N/A
C. Was pipe from tank discharge to pump suction visually inspected? ___________ □ Yes □ N/A
D. Copy of Contractor's Material and Test Certificate for Underground Piping attached? (See Figures A.14.1.3[b] and A.14.1.3[c]) ___________ □ Yes □ N/A

II. Hydrostatic Test (14.1.2)
A. Maximum pump discharge pressure at rated speed and no flow (churn) condition ___________ psi
B. Piping tested at ___________ psi for 2 hours? ___________ □ Yes □ No □ N/A
C. Piping passed test? ___________ □ Yes □ No □ N/A
D. Copy of Contractor's Material and Test Certificate for Fire Pump System attached? (See Figures A.14.1.3[a] and A.14.1.3[b]) ___________ □ Yes □ No □ N/A

III. People Present (14.2.1)
Were the following present to witness the test:
A. Pump manufacturer/representative? □ Yes □ No
B. Engine manufacturer/representative? □ Yes □ No □ N/A
C. Controller manufacturer/representative? □ Yes □ No
D. Transfer switch manufacturer/representative? □ Yes □ No □ N/A
E. Authority having jurisdiction/representative? □ Yes □ No
F. Owner or owner's representative? □ Yes □ No

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(NFPA 20, p. 1 of 4)
IV. Electric Wiring
A. Was all electric wiring including control interwiring for multiple pumps alternate power supply and the jockey pump completed and checked by the electrical contractor prior to the initial start-up and acceptance test? □ Yes □ No □ N/A

V. Flow Test
A. Is a copy of the manufacturer’s certified pump test curve attached? □ Yes □ No
B. Test results compared to the manufacturer's certified pump test curve? □ Yes □ No
C. Gauges and other test equipment calibrated? □ Yes □ No
D. No vibrations that could potentially damage any fire pump component? □ Yes □ No □ N/A
E. The fire pump performed at all conditions without objectionable overheating of any component? □ Yes □ No □ N/A
F. For each test, record the required information for each load condition using the following formulas (or other acceptable methods) and tables:

\[ P_{net} = P_{discharge} - P_{ suction} \]
\[ Q = \frac{0.825}{12} \left( \frac{P_{e}}{1200} \right)^{0.5} \]
\[ P_{f} = 0.8 \times 312V \left( \frac{a}{g} \right) \left( \frac{d}{1200} \right)^{0.5} \]

Where:
- \( P_{net} \): Net pump pressure (psi)
- \( P_{discharge} \): Total pressure at the pump discharge (psi)
- \( P_{suction} \): Total pressure at the pump suction (psi)
- \( Q \): Flow through a circular orifice (gpm)
- \( c \): Nurrle discharge coefficient
- \( d \): Nurrle orifice diameter (in.)
- \( P \): Pressure measured on gague (pilot)
- \( V \): Velocity of liquid (ft/sec)
- \( g \): Gravitational constant (32.174 ft/sec²)
- \( D \): Internal pipe diameter (in.)

<table>
<thead>
<tr>
<th>Test</th>
<th>Pump speed (rpm)</th>
<th>Nurrle size (in.)</th>
<th>Nurrle coeff.</th>
<th>Flow (gpm)</th>
<th>Net pressure (psi)</th>
<th>RPM regulated</th>
<th>RPM max</th>
<th>RPM max regulated</th>
<th>RPM max</th>
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</table>

Pump is □ Constant speed □ Variable speed

Notes:
1. Velocity pressure adjustments provide a more accurate analysis in most cases and as a minimum should be included whenever the pump suction and discharge diameters are different and the pump fails by a narrow margin. The actual internal diameter of the pump suction and discharge should be obtained from the manufacturer.
2. These readings are applicable to diesel engine pumps only. Recording these readings is not specifically required in Chapter 14.

For electric motor-driven pumps also record:

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<th>Test</th>
<th>Voltage</th>
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</table>

G. For electric motors operating at rated voltage and frequency, is the ampere demand less than or equal to the product of the full load amperes rating times the allowable service factor as stamped on the motor name plate? □ Yes □ No □ N/A

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<tr>
<th>Test Number</th>
<th>Number of Discharges</th>
<th>Driver RPMs</th>
<th>Power Supply Voltage</th>
<th>Suction EL/Ft</th>
<th>Discharge</th>
<th>Net</th>
<th>Flow P.</th>
<th>Disch. EL±Ft</th>
<th>Orifice Size</th>
<th>C</th>
<th>Each Outlet</th>
<th>Total</th>
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<td>463</td>
<td>68</td>
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</table>

**Sample Calculation**

- Adjusted: 137 psi
- Rating: 140 psi
- Adjusted: 134 psi
- Adjusted: 108 psi

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**Graph**

- **Test**
- **Rating**
- **Adjusted**

---

**Legend**

- Adjusted
- Rating
- Adjusted

---

**Note:** The chart provides a detailed analysis of pump performance, including discharge pressures, flow rates, and other relevant factors. The graph illustrates the pressure variations against flow rates, highlighting the adjusted values for better performance assessment.
### Table 8.1.1.2 Summary of Fire Pump Inspection, Testing, and Maintenance

<table>
<thead>
<tr>
<th>Item</th>
<th>Frequency</th>
<th>Reference</th>
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<tbody>
<tr>
<td><strong>Inspection</strong></td>
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<tr>
<td>Alignment</td>
<td>Annually</td>
<td>8.3.6.4</td>
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<tr>
<td>Cable/wire insulation</td>
<td>Annually</td>
<td>8.1.1.2.5</td>
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<tr>
<td>Diesel pump system</td>
<td>Weekly</td>
<td>8.2.2.4(4)</td>
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<tr>
<td>Electric pump system</td>
<td>Weekly</td>
<td>8.2.2.3</td>
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<tr>
<td>Engine crankcase breather</td>
<td>Annually</td>
<td>8.1.1.2.12</td>
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<tr>
<td>Exhaust system and drain condensate trap</td>
<td>Annually</td>
<td>8.1.1.2.13</td>
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<tr>
<td>Flexible hoses and connections</td>
<td>Annually</td>
<td>8.1.1.2.11</td>
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<tr>
<td>Fuel tank vents and overflow</td>
<td>Annually</td>
<td>8.1.1.2.10</td>
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<tr>
<td>Plumbing parts – inside and outside of panels</td>
<td>Annually</td>
<td>8.1.1.2.6</td>
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<tr>
<td>Printed circuit board corrosion (PCBs)</td>
<td>Annually</td>
<td>8.1.1.2.4</td>
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<tr>
<td>Pump</td>
<td>Weekly</td>
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<tr>
<td>Pump house/room</td>
<td>Weekly</td>
<td>8.2.2.1(1)</td>
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<td>Shaft movement or endplay while running</td>
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<td>Steam pump system</td>
<td>Weekly</td>
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<td>Suction screens</td>
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<td>Diesel fuel testing</td>
<td>Annually</td>
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<tr>
<td>Electric motor–driven fire pump</td>
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<td>Annually</td>
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<td>Fuel tank, float switch, and supervisory signal for interstitial space</td>
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<td>Main relief valve</td>
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<td>Control and power wiring connections</td>
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<td>Diesel engine system</td>
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<td>Electric motor and power system</td>
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<td>Engine oil filter</td>
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<td>Fuel tank – check for water and foreign materials</td>
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<td>8.1.1.2.9</td>
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<td>Measure back pressure on engine turbo</td>
<td>Annually</td>
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<td>Pressure gauges and sensors</td>
<td>Annually</td>
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<td>Pump and motor bearings and coupling</td>
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<td>Sacrificial anode</td>
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Evaluation of Fire Pump Test Results:

The fire pump test results shall be considered acceptable if both of the following conditions are satisfied:

1. Fire pump can supply the full system demand as provided by the owner.
2. Fire pump test results are no less than 95 percent of the flow rates and pressures at each point for either a or b:
   a. Original unadjusted field test curve
   b. Fire pump nameplate
Upon failure to meet the criteria following actions shall occur:

1. The owner shall be notified.
2. An investigation shall be conducted to reveal the cause of the degraded performance.
3. The deficiency shall be corrected.
Thank YOU