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

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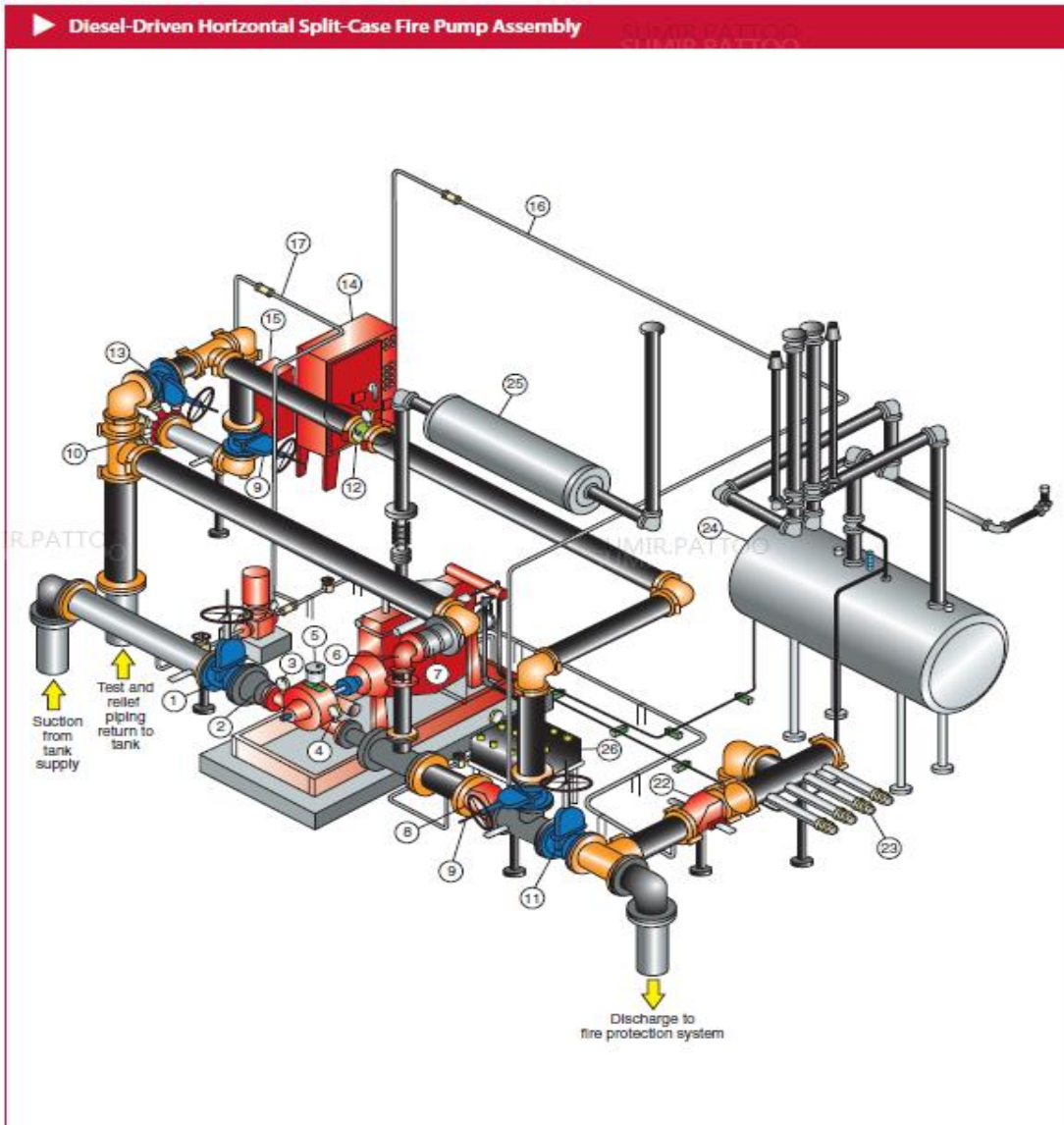


Definitions

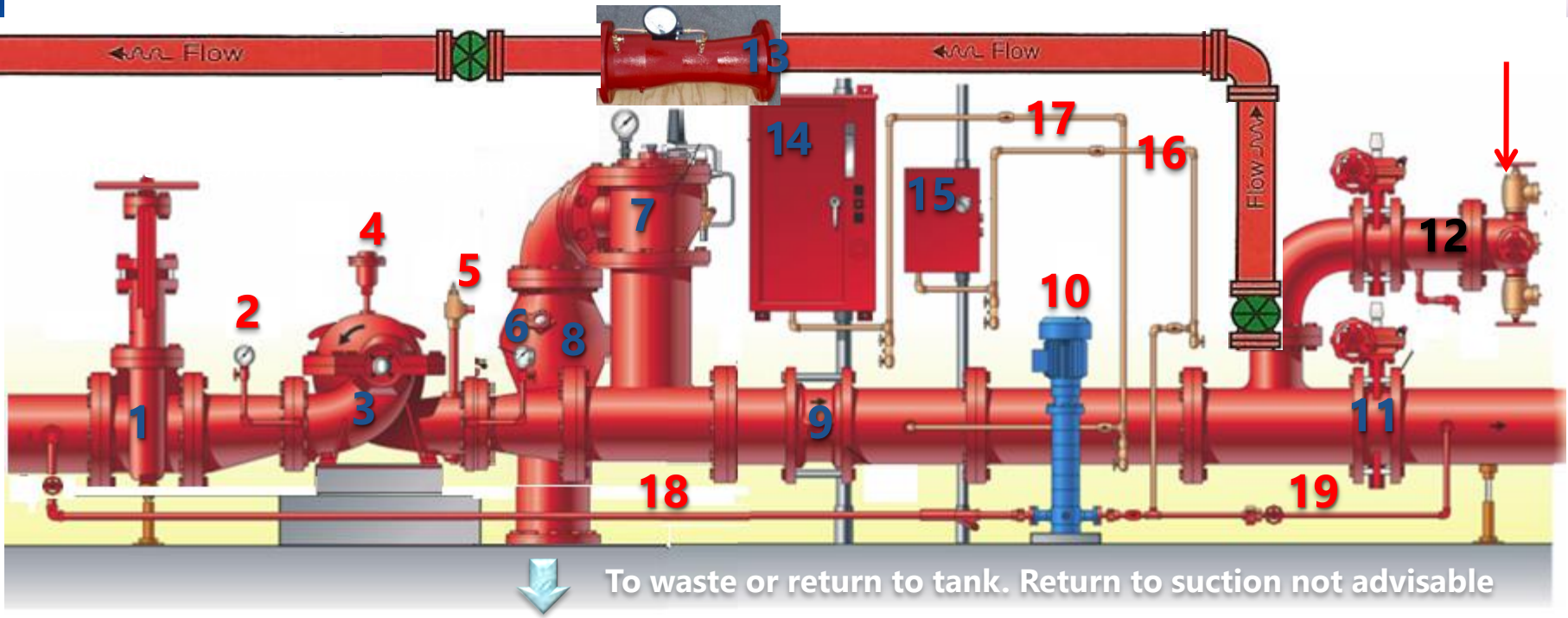
- ❖ Fire Pump Unit: An assembled unit consisting of a fire pump, driver, controller, and accessories.
- ❖ Fire Pump: A pump that is a provider of liquid flow and pressure dedicated to fire protection.
- ❖ Rated Flow: The capacity of the pump at rated speed and rated pressure as marked on the manufacturer's 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



General Layout of Fire Pump House



1. OS&Y Gate Valve w/TS

2. Compound Suction Gauge

3. Horizontal Split Case Fire Pump

4. Auto. Air Release Valve ½" min.

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

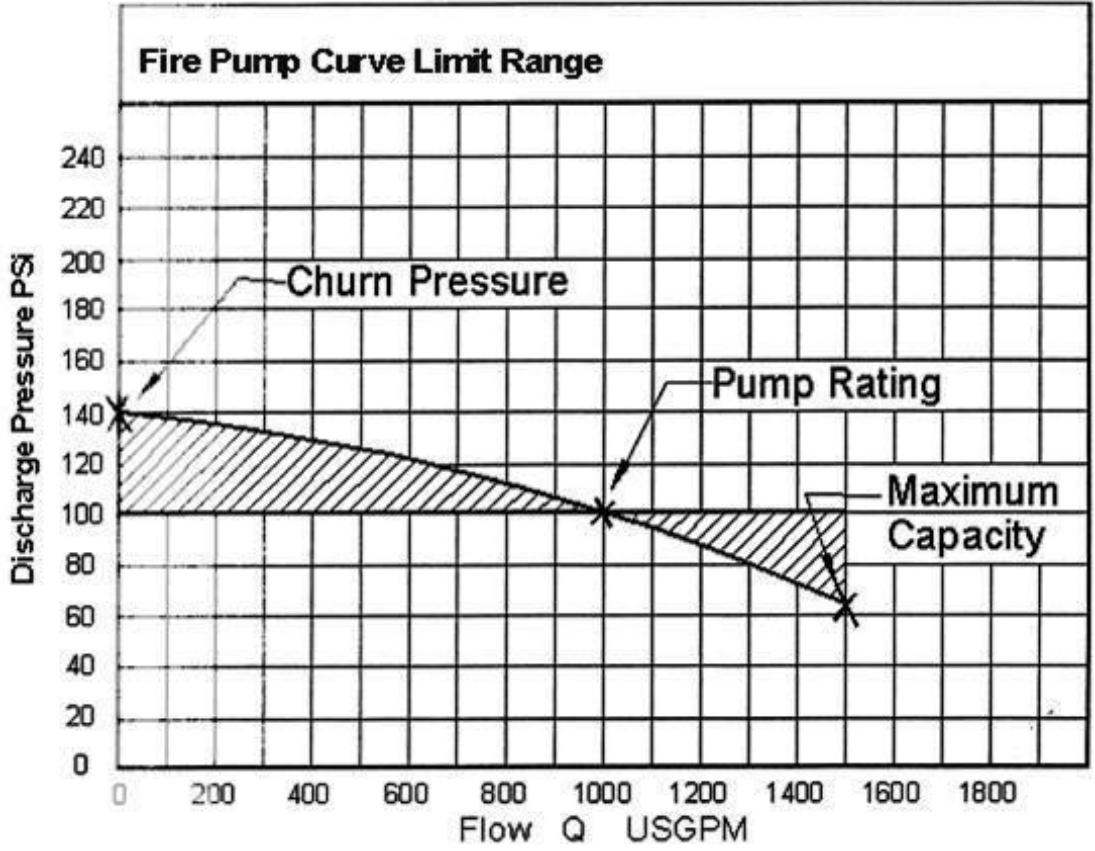
17. Fire Pump Sensing Line

18. Jockey Pump Suction

19. Jockey Pump Discharge



Selection and Addition Of Fire Pumps - Pump Curve Limit Range



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**



Example 1

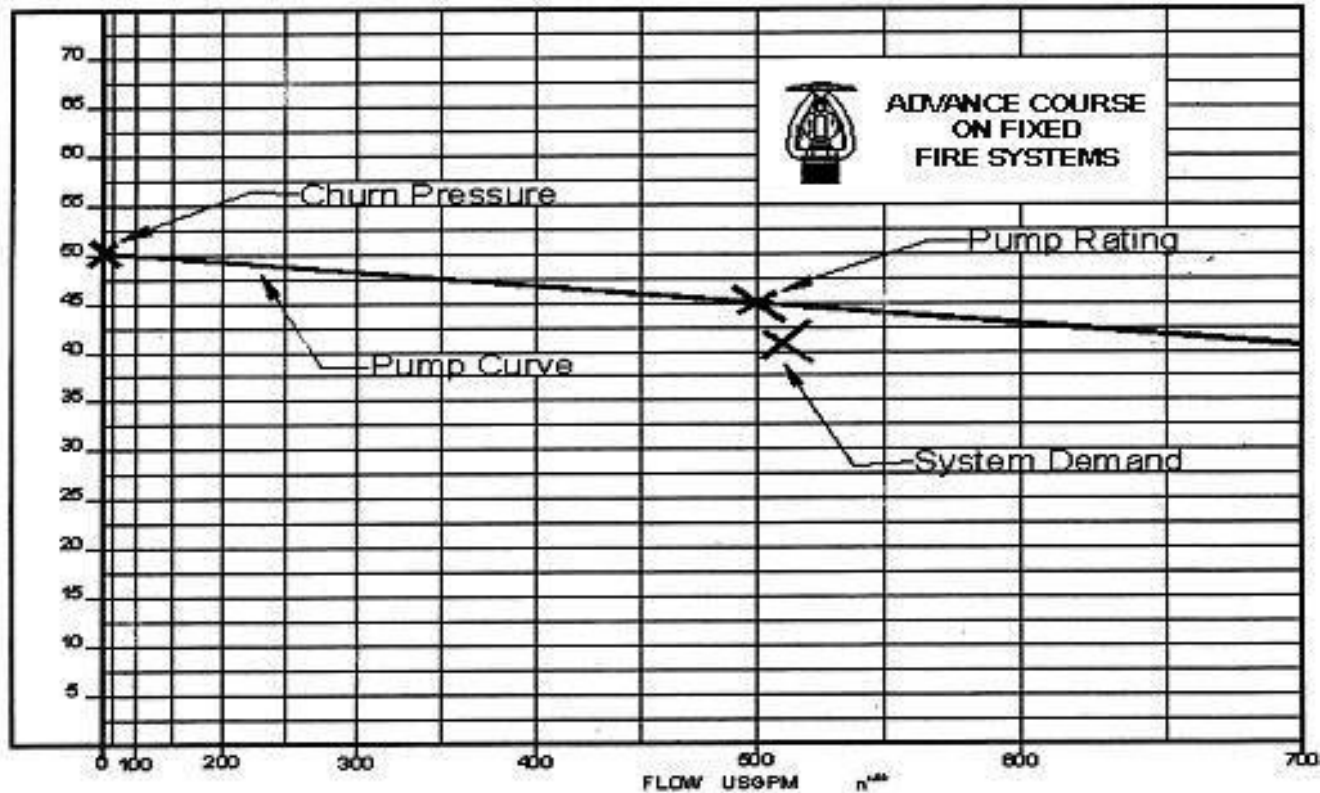
Calculating a sprinkler system you find demand is 510 GPM @ 42 PSI including a 250 GPM inside hose allowance. There is no city water supply and a lake is the water source. A vertical turbine pump is used due to the lake's lower elevation.

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

Pump has churn pressure of 50 PSI.



Example 1



The system demand point is below the pump curve; the pump will satisfy demand. The demand point is 3 PSI below the pump curve; the next pump, rated at 500 GPM @ 50 PSI, is a better choice.



Example 2

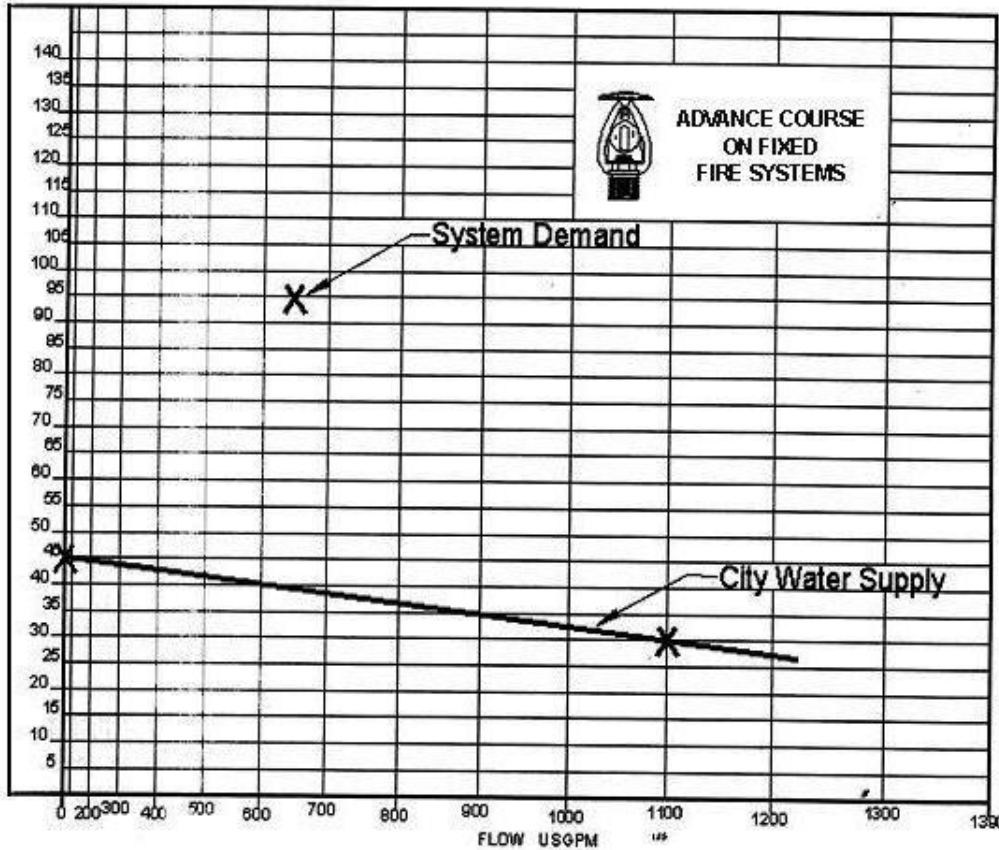
Calculating a sprinkler system and find demand is 650 GPM @ 95 PSI. The city water has a static pressure of 45 PSI, and a residual pressure of 30 PSI @1100 GPM.

The fire pump, rated at 600 GPM @ 65 PSI, is selected to boost pressure. The churn percentage is 120% and the pump is at 150% capacity at 51 PSI.

Is this the correct pump for the job?



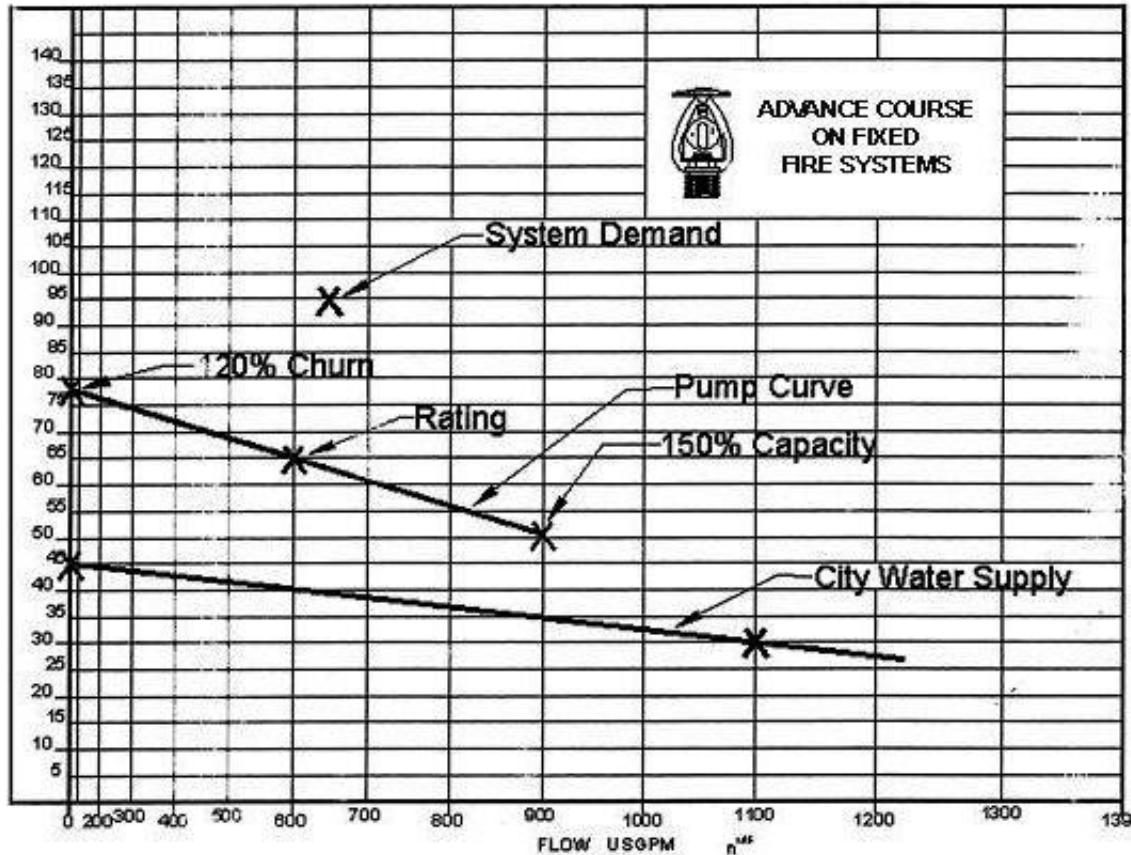
Example 2



Start by plotting city water supply and system demand



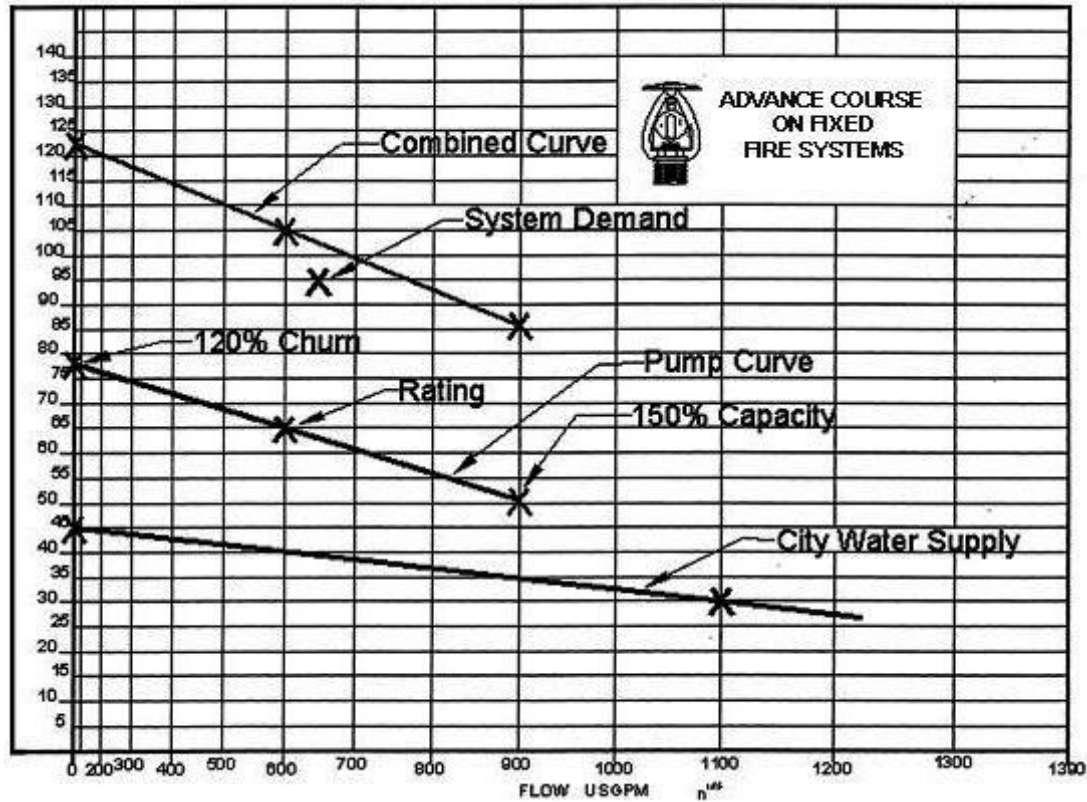
Example 2



You can then plot the pump curve on the graph



Example 2



The system demand point falls below the combined curve, which means the pump is adequate



Acceptance & Performance of Fire Pumps- NFPA 20

- ❖ **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 25.



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 _____ gpm at _____ 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, net capacity _____ gpm

Driver: _____ Electric motor _____ Diesel engine _____ Steam turbine _____

Manufacturer: _____ Shop/Serial number: _____ Model or type: _____

Rated horsepower: _____ Rated speed: _____ If electric motor, rated voltage _____ Operating voltage _____

Rated amps _____ Phase cycles _____ Service factor _____

Controller manufacturer: _____

Shop/Serial number: _____ Model or type: _____

Controller rated _____ HP _____ VAC

Does controller rated HP & VAC match motor? _____ Yes No

Transfer switch? _____ Yes No

Transfer switch rated _____ HP _____ VAC

Does controller rate HP & VAC match motor? _____ 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 valve 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: _____ Model or type: _____

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 14.1.1.1) — Conduct before hydrostatic test

- Suction supply from ground level storage tank or reservoir _____ Yes N/A
- Suction piping was flushed at _____ gpm? (See Table 14.1.1.1) _____ Yes No N/A
- Was pipe from tank discharge to pump suction visually inspected? _____ Yes No N/A
- 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 No N/A

II. Hydrostatic Test (14.1.2)

- Maximum pump discharge pressure at rated speed and nonflow (churn) condition _____ psi
- Piping tested at _____ psi for 2 hours? _____ Yes No N/A
- Piping passed test? _____ Yes No N/A
- Copy of Contractor's Material and Test Certificate for
Fire Pump Systems 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:

- Pump manufacturer/representative? _____ Yes No
- Engine manufacturer/representative? _____ Yes No N/A
- Controller manufacturer/representative? _____ Yes No
- Transfer switch manufacturer/representative? _____ Yes No N/A
- Authority having jurisdiction/representative? _____ Yes No
- Owner or owner's representative? _____ Yes No



IV. Electric Wiring

A. Was all electric wiring including control interwiring for multiple pump 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 formulae (or other acceptable methods) and tables:

$$P_{Net} = P_{Discharge} - P_{Suction}$$

$$Q = 99.83 c d^2 P^{0.5}$$

$$P_v = 0.433 H V^2 / (2g) = (Q^2) / (890.47 D^4)$$

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 = Nozzle discharge coefficient
- d = Nozzle orifice diameter (in.)
- P = Pressure measured on gauge (psig)
- P_v = Velocity pressure (psi)
- V = Velocity of liquid (ft/sec)
- g = Gravitational constant (32.174 ft/sec)
- D = Internal pipe diameter (in.)

Test	Pump speed (rpm)	Suction pressure (psi)	Discharge pressure (psi)	Nozzle size (in.) _____ Nozzle coef. _____						Flow (gpm)	Net pressure (psi)	Ipm adjusted net pressure ¹	Ipm adjusted flow (psi) ²	Suction velocity pressure (psi) ¹	Discharge velocity pressure (psi) ¹	Velocity adjusted pressure (psi) ¹	Oil pressure (psi) ³	Each on at back pressure (in. Hg)g	Diesel vent or temperature ⁴	Cooling keep pressure (psi) ²
				Pitot readings (psi)																
				1	2	3	4	5	6											
0%																				
25%																				
50%																				
75%																				
100%																				
125%																				
150%																				
0%																				
100%																				
150%																				

Pump is Constant speed Variable speed

Notes:
¹Velocity 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 section and discharge should be obtained from the manufacturer.
²These 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:

Test	Voltage			Amps		
	L1-L2	L2-L3	L1-L3	L1	L2	L3
0%						
25%						
50%						
75%						
100%						
125%						
150%						
0%						
100%						
150%						

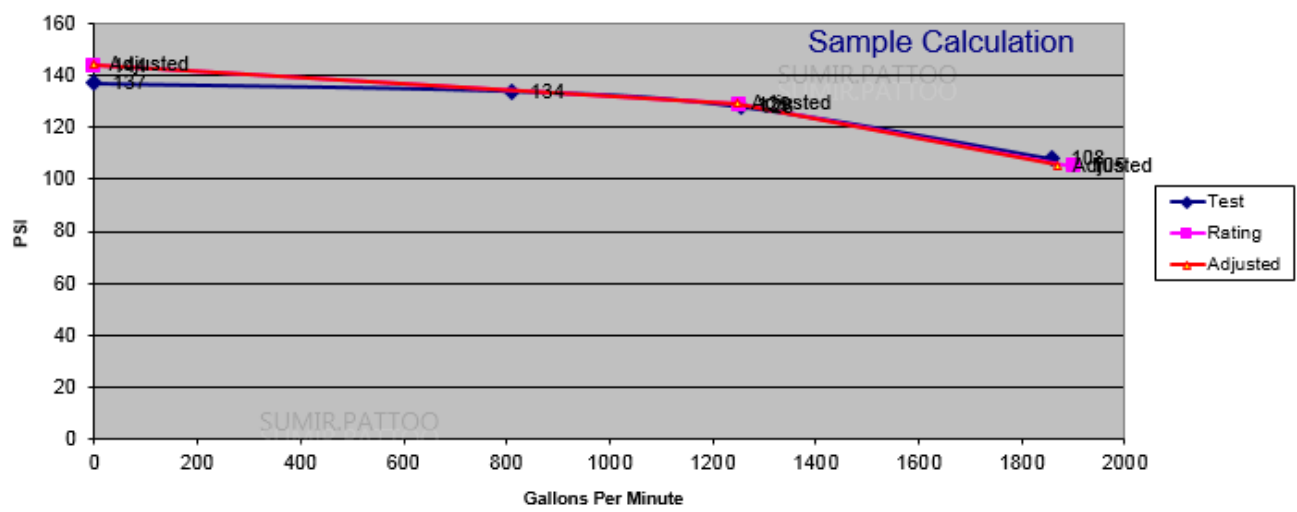
G. For electric motors operating at rated voltage and frequency, is the ampere demand less than or equal to the product of the full load ampere rating times the allowable service factor as stamped on the motor name plate? Yes No N/A



Date: March 21, 2018	Pump Manufacturer: SPP	HP: 150	SF Factor: N/A
Pump Location: Sample Calcula	Efficiency Rating: 76%	Voltage: 480 V	Amps: 150 HZ: Phase: 3
Pump ID #: X16-G-D111A	100% Rating: 1250 gpm	@ 130 psi	Rated Churn PSI: 145
Pump RPM Rating: 1785	150% Rating: 1875 gpm	@ 106 psi	PCVIPZV Rating: NA

Test Number	Number of Discharges	Driver RPMs	Power Supply			Pressures			Factors				Flows (GPMs)	
			Voltage	Amperes		Suction EL/FL	Discharge	Net	Flow P.	Disch. EL± Ft	Orifice Size "	C	Each Outlet	Total
Churn	N/A	1780	463	68	18	155	137	N/A	N/A	N/A	N/A	N/A	0	
Test 1	Discharge 1	1780	462	115	18	152	134						811	
Test 2	Discharge 2	1780	459	141	17	145	128						1256	
Test 3	Discharge 3	1780	460	156	16	135	119						1572	
Test 4	Discharge 4	1780	460	167	16	124	108						1860	

Page 1



Testing and Inspection Of Fire Pumps

Table 8.1.1.2 Summary of Fire Pump Inspection, Testing, and Maintenance

Item	Frequency	Reference
Inspection		
Alignment	Annually	8.3.6.4
Cable/wire insulation	Annually	8.1.1.2.5
Diesel pump system	Weekly	8.2.2(4)
Electric pump system	Weekly	8.2.2(3)
Engine crankcase breather	Annually	8.1.1.2.12
Exhaust system and drain condensate trap	Annually	8.1.1.2.13
Flexible hoses and connections	Annually	8.1.1.2.11
Fuel tank vents and overflow	Annually	8.1.1.2.10
Plumbing parts – inside and outside of panels	Annually	8.1.1.2.6
Printed circuit board corrosion (PCBs)	Annually	8.1.1.2.4
Pump	Weekly	8.2.2(2)
Pump house/room	Weekly	8.2.2(1)
Shaft movement or endplay while running	Annually	8.1.1.2.1
Steam pump system	Weekly	8.2.2(5)
Suction screens	Annually	8.3.3.7
Test		
Diesel engine–driven fire pump	Weekly	8.3.1.1
Diesel fuel testing	Annually	8.3.4
Electric motor–driven fire pump	Weekly/monthly	8.3.1.2
Fire pump alarm signals	Annually	8.3.3.5
Fuel tank, float switch, and supervisory signal for interstitial space	Quarterly	8.1.1.2.7
Main relief valve	Annually	8.3.3.3
Power transfer switch	Annually	8.3.3.4
Pump operation (no flow)		8.3.1
Pump performance (flow)	Annually	8.3.3
Supervisory signal for high cooling water temperature	Annually	8.1.1.2.8
Maintenance		
Batteries	Annually	8.1.1.2.15
Circulating water filter	Annually	8.1.1.2.20
Control and power wiring connections	Annually	8.1.1.2.16
Controller	Per manufacturer	8.5
Diesel engine system	Per manufacturer	8.5
Electric motor and power system	Per manufacturer	8.5
Electrical connections	Annually	8.1.1.2.2
Engine lubricating oil	Annually or 50 operating hours	8.1.1.2.17
Engine oil filter	Annually or 50 operating hours	8.1.1.2.18
Fuel tank – check for water and foreign materials	Annually	8.1.1.2.9
Measure back pressure on engine turbo	Annually	8.1.1.2.14
Pressure gauges and sensors	Annually	8.1.1.2.21
Pump and motor bearings and coupling	Annually or as required	8.5
Sacrificial anode	Annually	8.1.1.2.19



Testing and Inspection Of Fire Pumps

- ❖ **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**



Testing and Inspection Of Fire Pumps

- ❖ **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

