

**Reference Materials:** This exam also contains "accepted practice" questions not found in the reference material listed below.

**Pumping Apparatus DRIVER/OPERATOR Handbook 3<sup>rd</sup> edition.** Oklahoma State University, Stillwater, OK. (800) 654-4055 or [www.ifsta.org](http://www.ifsta.org) Chapters 2 5,7, 8, 9, 10, 11,14, 15, glossary.

**NFPA 1900:** Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances (**NFPA 1901 Chapters**) 2024 edition

**NFPA 1910:** Standard for the Inspection, Maintenance, Refurbishment, Testing and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels (**NFPA 1911 Chapters**) 2024 edition [www.nfpa.org](http://www.nfpa.org) 800-344-3555

Fire pump manufacturer's repair manuals (Hale, Waterous, Darley, Trident) [www.haleproducts.com](http://www.haleproducts.com)

[https://smhttp-ssl-61500.nexcesscdn.net/media/pdf/029-0020-63-0-C\\_Midship\\_Muscle\\_Pump\\_Manual.pdf](https://smhttp-ssl-61500.nexcesscdn.net/media/pdf/029-0020-63-0-C_Midship_Muscle_Pump_Manual.pdf)

[https://tridentdirect.com/images/companies/1/AirPrime\\_Install-Ops\\_Guide\\_01-21-19\\_email.pdf?1523384889866](https://tridentdirect.com/images/companies/1/AirPrime_Install-Ops_Guide_01-21-19_email.pdf?1523384889866)

[www.waterousco.com](http://www.waterousco.com) Search for F-1031 2114, 4212, 1000

[www.wsdarley.com](http://www.wsdarley.com) - Pump Operaton Manual - Midship pump

## LEARNING OBJECTIVES

1. **Hydraulic Principles:** Understand the hydraulic principles of water movement in pump operations.
  - a. Pressure
    - (1) Force per unit area
    - (2) Static pressure
    - (3) Measure of residual pressure
    - (4) Net pump pressure
      - (a) Friction loss
    - (5) Head pressure
  - b. Vacuum
    - (1) inches of mercury
  - c. Drafting
    - (1) Effect of Atmospheric pressure on vacuum
    - (2) Lift
  - d. Venturi application
    - (1) eductor
  - e. Cavitation/Water hammer
    - (1) Symptoms
    - (2) Cause/Prevention
    - (3) Pump RPM to pressure relationship
2. **Mechanical Principles of Pumps:** Understand the theory and mechanical principles of pumps, pump controls and accessories:
  - a. Positive-displacement pumps
    - (1) Vane Primers
      - (a) Sealing Lubricant
  - b. Centrifugal Pump
    - (1) Two-stage
      - (a) Route of water
      - (b) Transfer valve
        - (i) Volume/parallel
        - (ii) Pressure/series
    - (2) Packing/Mechanical seal
      - (a) Drip rate
        - (i) mechanical seal
        - (ii) packing
      - (b) Flinger/Slinger ring
      - (c) Stuffing box
      - (d) Purpose of packing adjustment
      - (e) Lantern rings
    - (3) Impeller Design
      - (a) Purpose of eye
    - (4) Housing stripping edge/cut water
    - (5) Priming methods
      - (a) Air Primer
      - (b) Exhaust Primer
  - c. Pressure control devices
    - (1) Relief valves
      - (a) Purpose
      - (b) Controls
      - (c) Pilot Valve
    - (2) Governors
      - (a) Controls
  - d. Intake and discharge valves
    - (1) Ball valve
  - e. Coolers
    - (1) Engine
    - (2) Pump
      - (a) Thermal relief valve
  - f. Foam system proportioning
  - g. Vernier throttle purpose
  - h. Gauges
    - (1) Compound Pressure gauge
    - (2) Liquid filled gauge
      - (a) Acceptable condition
  - i. Flow meters
    - (1) Mounting
    - (2) Paddle wheel
  - j. Water tank to pump check valve
3. **Fire Pump Operation:** Understand the operation of a fire pump and related accessories.
  - a. Pumping at Draft
    - (1) Two Stage
      - (a) Volume/Parallel
      - (b) Pressure/Series
      - (c) Transfer valve positioning
      - (d) Swing check valve
    - (2) Choosing a draft site
      - (a) Contamination
      - (b) Maximum allowable lift
    - (3) Vacuum
      - (a) Effect of Leaks
      - (b) Priming
      - (c) Vacuum readings when drafting
      - (d) Pump packing adjustment
    - (4) Reduced flow/losing prime - Cause & Effect
      - (a) worn impeller
      - (b) leak on intake
      - (c) aeration
      - (d) hoseliner collapse
  - (e) Transmission Lockup
  - (f) Relief Valve
  - (5) Pressure controlling systems
    - (a) Pressure relief valves
    - (b) Maximum pressure rise continued on other side
    - (c) intake relief valves
    - (d) Pilot valves
  - b. Auxiliary Cooling system
  - c. Butt Tooth condition during pump shifting
  - d. Cause of cavitation
  - e. Pump transmission

**4. Preventive Maintenance, Checks & Inspection:** Understand the periodic preventive maintenance and inspection requirements.

- a. Lubricant
  - (1) Types
  - (2) Primer pumps
  - (3) Fluid level check
  - (4) Hale Auto-lube front bearing
- b. Documentation
  - (1) PM
  - (2) Schedule responsibility
  - (3) Fluid analysis
- c. Frequency / Required monthly checks
  - (1) Flushing/Back Flushing
- d. Pump Packing
  - (1) Reason for Adjustment
  - (2) Cause/Effect of Incorrect Adjustment
  - (3) Maintenance
- e. Mechanical pump seals
  - (1) Acceptable leak rate
- f. Transfer Valve Maintenance
- g. Pump transmission
  - (1) Maintenance intervals
  - (2) Incorrect fluid levels
- (3) Drain plug function
- (4) Water Contamination
- (5) Leaks
  - (a) Class 3
- (6) Primer Maintenance
- (7) Oiled Primer leaks
- h. Pressure relief system
  - (1) Checks
  - (2) Maintenance
- i. Valve maintenance
- j. Gauges and instruments
  - (1) Flow meter Paddle wheel inspection
- k. Pump assembly
  - (1) Waterous Out board bearing Lubrication
- l. Anodes/Intake strainer inspection
- m. Water and foam tank maintenance
- n. Out of service
  - (1) Pressure Control system
  - (2) Water Tank
  - (3) Fire Pump engagement

**5. Repair and Overhaul:** Understand the necessary procedures to repair and overhaul a fire pump

- a. Probable Causes and Effects of defects
  - (1) Pump components
    - (a) Galvanic corrosion
    - (b) Impeller damage from Cavitation
    - (c) Shaft damage from packing
    - (d) Primer systems
      - (i) Primer Valve stuck open
      - (ii) Oiled primer leaks
      - (iii) Primer will not engage
    - (e) Pump transmission Fluid analysis
    - (f) Drive line out of phase
    - (g) Relief valve delayed response
    - (h) Valves
      - (i) leakage
      - (ii) locking
    - (i) Worn clearance ring effect
    - (j) Missing flinger / slinger ring
    - (k) Pump component specifications
  - (2) Pump Controls and accessories
    - (a) Transmission Lockup
    - (b) Gauge problems
    - (c) Improper operation
- b. Out of Service criteria
  - (1) Pump out of service requirements
  - (2) Pump out of service signage / warning
  - (3) Water tank level indicator
  - (4) Class 2 valve leak
- c. Procedures
  - (1) Proper impeller assembly
  - (2) Transfer valve removal
  - (3) Intake Valve installation
  - (4) Packing
    - (a) Installation
  - (5) Replacing mechanical seal
  - (6) Gauge troubleshooting
  - (7) Worn or Damaged parts
    - (a) Pump packing
    - (b) Impeller shaft
  - (8) Determining condition
    - (a) Pump performance
    - (b) Out of Service
    - (c) Safety - Reliability
  - (9) Special tools
  - (10) Workplace safety and cleanliness
- d. Reference material
  - (1) Pump info needed
  - (2) Utilizing technical/repair manuals

**6. Pump Performance Testing:** Understand the procedures of conducting a pump performance test.

- a. Repair and overhaul testing requirements
- b. Documentation
  - (1) Purpose of maintaining records
  - (2) Records retention
- c. Frequency of tests
- d. Setup and equipment
  - (1) Conditions
    - (a) Required Electric load during test
    - (b) Ambient air
    - (c) Water temperature
    - (d) Hydraulic Generator
    - (e) Salt water testing
    - (f) Test layout conditions
  - (2) Required equipment
    - (a) Pitot gauge
    - (b) Equipment to take RPM readings
    - (c) Required Test gauge Accuracy and Calibration
  - (3) Parallel/series
- e. Required Performance Tests
  - (1) Primer Test
    - (a) time requirements
  - (2) Vacuum test
    - (a) high altitude
  - (3) Overload pump test
  - (4) No load governor test
  - (5) Flow meter test
  - (6) Tank to pump flow test
  - (7) Pressure controlling device test
    - (a) Fire pumps/Wildland pumps
  - (8) Flow test
    - (a) Fire pumps/Wildland pumps
  - f. Calculating net pump pressure
  - g. Re-rating/de-rating pump
  - h. Troubleshooting
    - (1) Stuck swing check valves
    - (2) Draft problems / RPM not maintainable
    - (3) test pit aeration
    - (4) Causes for failing flow test
    - (5) Failed vacuum test
  - i. Out of Service
    - (1) Failure of test
    - (2) gauges
    - (3) signage
    - (4) inoperable pressure controlling device
    - (5) Engine overheat during test
    - (6) Leaks
      - (a) Class 3