

SECTION II

OBJECTIVES

FIRE APPARATUS ENGINEER COURSE OBJECTIVES

I. General

- 11-1-1** The Fire Apparatus Engineer shall explain the following terms: atmospheric pressure, capacity, discharge velocity, displacement, flow GPM, flow pressure, friction loss, head pressure (gain or loss), hydrant pressure, negative pressure, net engine pressure, normal engine pressure, normal operating pressure, nozzle reaction, PSI (pressure per square inch), pump discharge pressure, residual pressure, static pressure, vacuum, velocity, water hammer.

II. Preventive Maintenance

- 11-2-1** The Fire Apparatus Engineer shall identify apparatus and equipment preventive maintenance requirements including general and special purpose equipment which require that maintenance be performed in accordance with local procedures and manufacturers technical data. (*NFPA 1002, 2-2*)
- 11-2-2** The Fire Apparatus Engineer shall perform inspections and service functions required to assure the operational status of the apparatus and its complement of equipment. (*NFPA 1002, 2-2.1, 3-1.1*)

III. Pumps

- 11-3-1** The Fire Apparatus Engineer shall explain the principles of operation, components and advantages and disadvantages of a positive displacement pump. (*NFPA 1002, 3-2.1, NFPA1904, 12-10.10, 12-13.5, 14-9.8, 14-12.3.1*)
- 11-3-2** The Fire Apparatus Engineer shall explain the principles of operation, components, advantages and disadvantages, and methods of power transfer from engine to pump of a centrifugal pump. (*NFPA 1002, 3-2.1, NFPA1901, 12-10.2, 12-10.8*)
- 11-3-3** The Fire Apparatus Engineer shall identify common pump capacities. (*NFPA 1002, 3-2.1; NFPA 1901, 12-2.3.1, NFPA1911, 3-3.4*)
- 11-3-4** The Fire Apparatus Engineer shall identify the operating principles of single-stage and multi-stage centrifugal fire pumps. (*NFPA 1002, 3-2.2(b); NFPA 1901, 12-2.3.2*)
- 11-3-5** The Fire Apparatus Engineer shall identify the principles of drafting. (*NFPA 1002, 3-2.2(b); NFPA 1901, 12-2.4*)
- 11-3-6** The Fire Apparatus Engineer shall identify the characteristics and limitations of hard, flexible, and soft supply hose. (*NFPA 1002, 3-2.1(b); NFPA 1901, 3-7.2, 4-6.2, 12-13.2.2.1*)

IV. Pump Controls

- 11-4-1** The Fire Apparatus Engineer shall identify the operating principles and functions of the transfer valve. (*NFPA 1002, 3-2.1(b); NFPA 1901, 12-10.8*)
- 11-4-2** The Fire Apparatus Engineer shall identify the pump and engine cooling devices. (*NFPA 1002, 3-2.1; NFPA 1901, 8-2.2, 12-3.5*)

- 11-4-3 The Fire Apparatus Engineer shall identify the functions and operations of priming devices. (*NFPA 1002, 3-2.1; NFPA 1911,3-3.3, 12-10.10, 12-13.5*)
- 11-4-4 The Fire Apparatus Engineer shall identify the operating principles and needs of the pressure control devices. (*NFPA 1002, 3-2.2, NFPA1901, 12-10.9, NFPA1911, 3-3.5*)
- 11-4-5 The Fire Apparatus Engineer shall identify all pump gauges and demonstrate their use. (*NFPA 1901, 12-12.1 – 12-12.5*)

V. Water Supply

- 11-5-1 The Fire Apparatus Engineer shall identify types of hydrants. (*NFPA 1002, 3-2.1*)
- 11-5-2 The Fire Apparatus Engineer shall identify problems related to dead-end water mains. (*NFPA 1002, 3-2.2(a)*)
- 11-5-3 The Fire Apparatus Engineer, given reference materials, shall identify and explain the approximate pressure-discharge relationship for various water pipe sizes. (*NFPA 1002, 3-2*)
- 11-5-4 The Fire Apparatus Engineer shall identify at least two causes of increased resistance or friction loss with water flowing in water mains. (*NFPA 1002, 3-2.2*)
- 11-5-5 The Fire Apparatus Engineer shall identify the NFPA recommended color code system for fire hydrants. (*NFPA 1002, 3-2.1*)
- 11-5-6 The Fire Apparatus Engineer shall identify private water supply systems and explain the operation, care and maintenance of those systems. (*NFPA 1002, 3-2.4*)
- 11-5-7 The Fire Apparatus Engineer shall ascertain the expected fire flow, given a specified location, a water source, and water supply information for that location, so that the amount of water available for firefighting at the location is estimated and alternative sources of water are identified. (*NFPA 1002, 3-2.4*)
- 11-5-8 The Fire Apparatus Engineer shall identify the components of mobile water supply operations. (*NFPA 1002, 8-2, NFPA1901, Chapter 5*)
- 11-5-9 The Fire Apparatus Engineer shall position a fire department pumper to operate at a fire hydrant and static supply source utilizing each existing pumper intake connection, given a pumper, a length of intake hose, appropriate fittings or tools, so that the intake hose can be connected, without kinks, to the pump connection and without repositioning the vehicle. (*NFPA 1002, 3-2.2, Appendix A,3-1.3*)

VI. Calculations (*NFPA 1002, 3-2*)

- 11-6-1 The Fire Apparatus Engineer shall identify and demonstrate the use of proportions in mathematical calculations as required to solve fire department pumper hydraulic problems.
- 11-6-2 The Fire Apparatus Engineer shall mentally calculate the engine pressure required to supply elevated streams.

- 11-6-3 The Fire Apparatus Engineer shall identify GPM flows at standard tip pressures.
- 11-6-3.1 The Fire Apparatus Engineer shall identify the elements of friction loss.
- 11-6-4 The Fire Apparatus Engineer, given a series of fire ground situations, shall mentally calculate pump pressure, GPM, friction loss and nozzle pressure.

VII Operations

- 11-7-1 The Fire Apparatus Engineer, given a series of fire ground situations and using the written formulas contained in the course handout, shall determine: (*NFPA 1002, 3-2*)
 - A. Nozzle or pump discharge pressures when the length and size of nozzle is given.
 - B. Water flow in gallons per minute (gpm) when the diameter of the orifice and pressure at the orifice are given.
 - C. Friction loss in the supply and attack lines when the GPM is given.
 - D. Friction loss in Siamese lines when size of hose and GPM flow are given.
 - E. Friction loss in wyed lines when size of hose and GPM flow are given.
 - F. Friction loss in multiple lines when the size of hose and GPM flow are given.
 - G. An estimated remaining available volume from a hydrant while pumping a given volume.
- 11-7-2 The Fire Apparatus Engineer, given a fire department pumper, shall demonstrate the method(s) of power transfer from vehicle engine to pump. (*NFPA 1002, 3-2.1 (b)*)
- 11-7-3 The Fire Apparatus Engineer, given a fire department pumper and a series of fire ground situations, shall produce effective hand and master streams specified by the course content. (*NFPA 1002, 3-2.2*)
- 11-7-4 The Fire Apparatus Engineer shall demonstrate correct operations of the throttle to obtain and maintain each discharge pressure, within 10 psi (plus or minus) of the required pressures. (*NFPA 1002, 3-2.1*)
- 11-7-5 The Fire Apparatus Engineer, given a fire department pumper and drafting conditions, shall demonstrate a systems check when the pumper will not draft. (*NFPA 1911, B-2*)
- 11-7-6 The Fire Apparatus Engineer, given a fire department pumper, shall demonstrate the following operations: (*NFPA 1911, 3-3.4*)
 - A. Pump at maximum delivery rate from the apparatus water tank.
 - B. Pump at maximum rated capacity from a hydrant.
 - C. Pump at maximum rated capacity from draft.
 - D. Pump in relay (in-line) operation, per course handout

- 11-7-7** The Fire Apparatus Engineer, given a fire department pumper with multiple-stage pump, shall demonstrate the operation of the volume/pressure transfer valve under actual pumping conditions. (*NFPA 1002, 3-2.1, NFPA 1901, 12-2.3.2, NFPA 1911, 3-3.4.2*)
- 11-7-8** The Fire Apparatus Engineer, given a selection of nozzles and tips, shall identify the type, design, operation, nozzle pressure, and flow in GPM for proper operation of each as described in course content. (*NFPA 1002, 3-2.2(b)*)
- 11-7-9** The Fire Apparatus Engineer, given a fire department pumper, shall demonstrate the operation of the pumper pressure relief system, or the pressure control governor, or both. (*NFPA 1002, 3-2.1, NFPA 1911, 3-3.4(b)*)
- 11-7-10** The Fire Apparatus Engineer, given a fire department pumper, shall demonstrate the operation of the auxiliary cooling system. (*NFPA 1901, 3-2.2*)
- 11-7-11** The Fire Apparatus Engineer, given a series for fire ground situations, shall identify the capabilities and limitations of the water supply operations. (*NFPA 1002, 3-2.1*)
- 11-7-12** The Fire Apparatus Engineer, shall identify: (*NFPA 1002, 3-2.1*)
- A. Four types of master stream devices
 - B. Purpose of stream straighteners
 - C. The friction loss elements for course purposes
 - D. Operating pressures
 - E. Pressures for fog and straight tips (nozzles)
 - F. Rules for applying master streams
 - G. The angle of penetration and deflection of effective fire streams
 - H. Limits and correct placement of apparatus to achieve maximum results
- 11-7-13** The Fire Apparatus Engineer shall identify the method of calculating engine pressure including friction loss for aerial ladder pipes, elevation (head pressure) and loss for pre-piped waterways. (*NFPA 1002, 4-2.5*)
- 11-7-14** The Fire Apparatus Engineer shall identify the correct operation of discharge gate valves, in such a manner as to reflect an understanding of principles learned in the classroom. (*NFPA 1002, 3-2*)
- 11-7-15** The Fire Apparatus Engineer shall identify the function of the bleeder valves, drain valves, tank to pump valve, and recirculating valves. (*NFPA 1901, 12-6.5, 12-7.5*)

- 11-7-16** The Fire Apparatus Engineer shall identify the function of: (*NFPA 1002, 3-4.1.2*)
- A. Throttle
 - B. Proportioners
 - C. Gauge dampers
 - D. Grease fittings
 - E. Panel lights
 - F. Tank fill
 - G. Discharge outlets
 - H. Booster tank level (gauge)
 - I. Intakes (ports and/or gates)

VIII Supply and Support of Sprinklers and Standpipe Systems (*NFPA 1002, 3-2.4*)

- 11-8-1** The Fire Apparatus Engineer, given a check valve on the fire department connection to an automatic sprinkler system, shall demonstrate the direction of water flow through the valve.
- 11-8-2** The Fire Apparatus Engineer shall demonstrate the method specified to supply water to fire sprinkler and standpipe systems, given specific system information and a fire department pumper, so that water is supplied to the system at the proper volume and pressure.
- 11-8-3** The Fire Apparatus Engineer, given specific information on a sprinkler system, shall identify the number of sprinkler heads that can be adequately supplied by various capacity fire department pumpers.
- 11-8-4** The Fire Apparatus Engineer, given specific information on a sprinkler system, shall calculate the hose layouts, pump discharge pressure, and procedures to adequately supply water to that sprinkler system.
- 11-8-5** The Fire Apparatus Engineer, given specific information on a standpipe system, shall calculate the hose layouts, pump discharge pressure, and procedure to adequately supply water to that standpipe system.
- 11-8-6** The Fire Apparatus Engineer shall identify the proper methods and procedures to supply a standpipe system if the fire department connection is not usable.
- 11-8-7** The Fire Apparatus Engineer shall identify at least one method of determining actual water flow into a standpipe system, using handout content example.

IX Foam and Specialized Equipment (*NFPA 1002, 3-2.3*)

- 11-9-1** The Fire Apparatus Engineer shall define classification/types of foams, their capabilities; limitations and the operating principles of proportioning devices.
- 11-9-2** The Fire Apparatus Engineer shall identify matching nozzles and proportioning devices: figure percentages of foam and water.
- 11-9-3** The Fire Apparatus Engineer, given a selection of foam nozzles and eductors, shall identify the type, design, operation, operating pressure, and flow in GPM for proper operation of each.

X Pumping Apparatus Tests (*NFPA 1002, 3-1.1; NFPA 1901, 1996; NFPA 1911, 1997*)

- 11-10-1 The Fire Apparatus Engineer shall identify requirements that the pump be tested for certification in accordance with *NFPA 1901, Chapters 12-13*.
- 11-10-2 The Fire Apparatus Engineer shall identify requirements that the pump be tested for acceptance in accordance with *NFPA 1901, Chapters 12-13*.
- 11-10-3 The Fire Apparatus Engineer shall identify requirements that the pump be tested for delivery as specified by purchaser.
- 11-10-4 The Fire Apparatus Engineer shall identify: (*NFPA 1911, Chapter 3*)
 - A. The frequency and requirements for pump service tests.
 - B. Duration (time) of service tests.
 - C. Agency responsible for conducting service tests.
 - D. The equipment required to perform the service test.
 - E. Lift height required for the service test.
- 11-10-5 The Fire Apparatus Engineer shall identify when dry vacuum test is given; the: (*NFPA 1901, Chapters 12-13*)
 - A. Purpose of the test
 - B. Methods of testing
 - C. Duration (time) of test
 - D. Testing variations
- 11-10-6 The Fire Apparatus Engineer shall identify: (*NFPA 1901, Chapters 2-12*)
 - A. Loading
 - B. Acceleration and speed
 - C. Time and distance requirements
 - D. Required braking tests
- 11-10-7 The Fire Apparatus Engineer shall operate pressure relief devices. (*NFPA 1901, 12-10.9*)

XI Troubleshooting/Problems Occurring During Pump Operations (*NFPA1911, B-2*)

- 11-11-1 The Fire Apparatus Engineer shall explain common problems which occur while pumping, including the following conditions that may result in pump damage or unsafe operations; and their solutions:
 - A. Cavitation
 - B. Leaking fuel, oil or water
 - C. Overheating
 - D. Unusual noises
 - E. Vibrations
 - F. Water Hammer
 - G. Pump engagement indicator lights
 - H. Improper use of pressure relief or governing systems
 - I. Transfer valve
 - J. Failure to prime or loss of prime

SPECIFIC OBJECTIVES THAT THE RESPONSIBILITY OF THE LOCAL AUTHORITY HAVING JURISDICTION ARE:

NFPA 1002 (1998):

- 11-12-1 The Fire Apparatus Engineer shall be licensed to drive all vehicles they are

- expected to operate in accordance with applicable state and local laws.. (1-3.1)
- 11-12-2** The Fire Apparatus Engineer shall be subject to periodic medical evaluation, as specified by the authority having jurisdiction, to determine physical ability adequate for performance of duties as an operator of fire department vehicles. (1-3.2)
- 11-12-3** All firefighters who drive fire department vehicles or apparatus under emergency response conditions shall meet the objectives specified in Chapter 2, Driving/Operating. (1-3.3)
- 11-12-4** The Fire Apparatus Engineer shall demonstrate the recording and the reporting, as specified by the authority having jurisdiction, of all servicing functions. (2-2)
- 11-12-5** The Fire Apparatus Engineer shall identify all applicable state and local laws of the authority having jurisdiction, including rules and regulations governing the safe driving and operating of fire department vehicles. (2-3.1)
- 11-12-6** The Fire Apparatus Engineer, given a fire department vehicle, shall identify all automotive gauges and demonstrate their usage. (2-3)
- 11-12-7** The Fire Apparatus Engineer shall ascertain the expected fire flow, given a specific location, a water source and water supply information for that location, so that the amount of water available for firefighting at the location is estimated and alternative sources of water are identified. (3-2.1)
- 11-12-8** The Fire Apparatus Engineer shall identify the pipe sizes used in water distribution systems for residential, business, and industrial districts served by the authority having jurisdiction. (3-2.4)
- 11-12-9** The Fire Apparatus Engineer, given a fire department pumper, shall locate, identify, and demonstrate the operation of all equipment carried on or attached to that pumper. (*Chapter 3*)
- 11-12-10** The Fire Apparatus Engineer shall demonstrate the method specified to supply water to fire sprinkler and standpipe systems, given specific system information and a fire department pumper, so that water is supplied to the system at the proper volume and pressure. (3-2.4)
- 11-12-11** The Fire Apparatus Engineer shall pump a supply line of 2-1/2 in (65 mm) or larger, given a relay pumping evolution, the length and size of the line, desired flow and intake pressure, so that the proper pressure and flow are provided to the next pumper in the relay. (3-2.2)
- 11-12-12** The Fire Apparatus Engineer shall produce a foam fire stream, given foam-producing equipment, so that properly proportioned foam is provided. (3-2.3)
- 11-12-13** The Fire Apparatus Engineer shall change water supply from the apparatus water tank to an external source, given a pumper with an operating fire attack line of 1 1/2 in. (38 mm) or larger, so that the flow of water to the attack line is not interrupted and the proper pressure is maintained. (3-2.1)
- 11-12-14** The Fire Apparatus Engineer shall perform the specified routine tests, inspections, and servicing functions listed below, in addition to those contained

in 2-2.1, given a fire department pumper and its manufacturer's specifications, so that the operations status of the pumper is verified. (3-1.1)

NFPA 1500 (1997):

- 11-13-1** Fire department vehicles shall be operated only by members who have successfully completed an approved driver training program or by student drivers who are under the supervision of a qualified driver. Driver operators of fire apparatus shall meet the requirements specified in *Chapter 3* of this standard. (4-2.1)
- 11-13-2** Drivers of fire department vehicles shall have valid driver's licenses. Vehicles shall be operated in compliance with all traffic laws, including sections pertaining to emergency vehicles, and any other requirements of the authority having jurisdiction. (4-2.2)
- 11-13-3** During non-emergency travel, drivers of fire department vehicles shall obey all traffic control signals and signs, and all laws and rules of the road of the jurisdiction for all the operation of motor vehicles. (4-2.5)
- 11-13-4** The fire department shall develop written standard operating procedures for safely driving fire department vehicles during non-emergency travel and emergency response and shall include specific criteria for vehicle speed, crossing intersections, and traversing railroad grade crossing, and the use of emergency warning devices. Such procedures for emergency response shall emphasize that the safe arrival of fire department vehicles at the emergency scene is the first priority. (4-2.6)
- 11-13-5** The fire department shall develop written standard operating procedures requiring drivers to discontinue the use of manual brake limiting valves, frequently labeled as "wet road/dry road" switch, and requiring that the valve/switch remains in the "dry road" position. (4-2.10)
- 11-13-6** Drivers of fire department vehicles shall be directly responsible for the safe and prudent operation of the vehicles under all conditions. When the driver is under the direct supervision of an officer, that officer shall also assume responsibility for the actions of the driver. (4-2.3)
- 11-13-7** Drivers shall not move fire department vehicles until all persons on the vehicle are seated and secured with seat belts or in approved riding positions, other than specifically allowed in 4-3.1.1 of this chapter. (4-2.4)

- 11-13-8** During nonemergency travel, drivers of fire department vehicles shall obey all traffic control signals and signs, and all laws and rules of the road of the jurisdiction for the operation of motor vehicles. (4-2.5)

AERIAL LADDER OPERATIVE OBJECTIVES

Optional

NFPA 1002 (1998)

- 11-14-1** The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall be able to perform the routine tests, inspection, and servicing functions listed below, in addition to those specified in 2-2.1, given a fire department aerial apparatus, so that the operation readiness of the aerial apparatus is verified: (4-1.1)
- a) Cable systems (if applicable)
 - b) Aerial device hydraulic systems
 - c) Slides and rollers
 - d) Stabilizing systems
 - e) Aerial device safety systems
 - f) Breathing air systems
 - g) Communication systems
- 11-14-2** The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall perform the practical driving exercises specified in 2-3.2 through 2-3.5, given a fire department aerial apparatus and a spotter for backing, so that each exercise is performed safely without striking the vehicle or obstructions. (4-1.2)
- 11-14-3** The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall operate a fire department aerial apparatus over a predetermined route on a public way, using the maneuvers specified in 2-3.1, so that the vehicle is safely operated in compliance with all applicable state and local laws, departmental rules and regulations, and the requirements of *NFPA 1500, Section 4-2*. (4-1.3)
- 11-14-4** The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall have knowledge of the capabilities and limitations of aerial devices related to reach, tip load, angle of the inclination, and angle from chassis axis; effects of topography, ground and weather conditions on safe deployment, and use of the aerial device. (4-2.1)
- 11-14-5** The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall have knowledge of the aerial apparatus hydraulic systems, manufacturer's specifications for stabilization, stabilization requirements, effects of topography and ground conditions on safe stabilization. (4-2.2)

- 11-14-6 The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall have knowledge of the aerial device hydraulic systems, hydraulic pressure relief systems, gauges and controls, cable systems, communication systems, electrical systems, emergency operating systems, locking systems, manual rotation and lowering systems, stabilizing systems, aerial device safety systems, system overrides and the hazards of using overrides, safe operational limitations of the given aerial device, safety procedures specific to the device, and operations near electrical hazards and overhead obstructions. (4-2.3)
- 11-14-7 The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall lower the aerial device using the emergency operating system so that the aerial device is safely lowered to its bedded position. (4-2.4)
- 11-14-8 The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall have knowledge of nozzle reaction, range of operation, weight limitations. (4-2.5)

TILLER OPERATIVE OBJECTIVES

Optional

NFPA 1002 (1998)

- 11-15-1 The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall perform the practical driving exercises from the tiller position specified in 2-3.2 through 2-3.5, from the tiller position, given a qualified driver, fire department aerial apparatus equipped with a tiller and a spotter for backing, so that each exercise is performed safely without striking the vehicle or obstructions. (5-2.1)
- 11-15-2 The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall operate a fire department aerial apparatus equipped with a tiller from a tiller position, given a qualified driver, a fire department aerial apparatus equipped with a tiller, and a spotter for backing, over a predetermined route on a public way, using the maneuvers specified in 2-3.1, so that the vehicle is safely operated in compliance with all applicable state and local laws, departmental rules and regulations and the requirements of *NFPA 1500, Section 4-2*. (5-2.2)
- 11-15-3 The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall have knowledge of the principles of tiller operation, methods of communication with the driver, the effects on vehicle control or general steering reactions, night driving, negotiating intersections, and manufacturer's operation limitations, (5-2.2)
- 11-15-4 The Fire Apparatus Engineer/Pumping Apparatus Operator/Driver shall have knowledge of the principles of positioning and stabilizing the aerial apparatus from the tiller position. (5-2.3)