

**Reference Materials:** Note: This exam also contains many hands-on type questions you may not find in any reference material listed below  
 NFPA reference listed below - National Fire Protection Association, Quincy, MA, (800) 344-3555 or www.nfpa.org  
 NFPA 1901, **Standard for Automotive Fire Apparatus** Chapter 13  
 NFPA 1911, **Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus**  
 Chapters 3, 6, 9, 14, 20, 25  
**Any** Heavy Truck Electrical Manual-- Suggestions for electrical reference material are listed below.  
**Heavy Duty ProClinic Manual**, by Interstate Battery call Jeff Barron at 469-221-4655 for local interstate dealer ordering info  
**OR Auto Electricity & Electronics**, by James Duffy, Goodheart-Wilcox publisher 708-687-5000 or online retailers  
 Any emergency apparatus service and operator manual (OEM)

### LEARNING OBJECTIVES FOR THE F-4 EXAM

#### 1. Basic Principles of Electricity-Define or identify:

- a. Principles of electron flow
  - (1) Causes of resistance in circuits
  - (2) Definitions and terms
  - (3) Current flow in parallel circuits
  - (4) Current flow in series circuits
  - (5) Controlling current
  - (6) Spike suppression
- b. Ohms Law as applied to electrical circuits
  - (1) Relationship of volt, amp, resistance
  - (2) Calculating resistance in parallel circuits
  - (3) Units of measure for Ohm's Law
  - (4) Calculating resistance and voltage in series circuits
- c. Principles of electromagnetism
  - (1) How an electromagnet is created
  - (2) Uses of electromagnet
  - (3) Straight conductor vs. coiled conductor
- d. Electrical symbols and schematics
  - (1) Switch & relay symbol & terminal identification
  - (2) General circuit & symbols, i.e. ground, motors, etc
- e. Power Formulas as applied to Electrical circuits
  - (1) Relationship of volts, amps, & watts
  - (2) Calculating power, amp, and voltage requirements
- f. Circuit types
  - (1) Series & parallel
  - (2) Combo series/parallel
  - (3) Shielded Circuits

#### 2. Basic Principles of Operation-Describe or identify:

- a. Function & application of electrical components and accessories
  - (1) relays & diodes
  - (2) switches
  - (3) solenoids
  - (4) interlocks
  - (5) interface
  - (6) inverter & convertors
  - (7) load managers & sequencer
  - (8) electronic throttles
  - (9) ECM/ECU
- b. Function and application of electronic components
  - (1) diodes
  - (2) capacitors
  - (3) resistors
  - (4) lighting-incandescent, halogen, L.E.D., & strobes
  - (5) data buses
  - (6) multiplexing
  - (7) traffic preemption devices
- c. System requirements and performance evaluation
  - (1) voltage drop, current draw, resistance
- d. Evaluation of wire size, insulation, and circuit protection
  - (1) Fuses and circuit breakers-types
  - (2) insulation ratings
  - (3) wire gauge size
- e. Proper wire repair procedures and proper routing techniques
  - (1) Solder techniques
  - (2) wire termination, terminal & crimping tool
  - (3) wire loom ratings
  - (4) corrosion protections
- f. Equipment and component protection
  - (1) welding precautions
  - (2) spike protections
  - (3) static discharge
- g. Function, operation, & testing of gauges & warning devices
  - (1) ammeters, voltmeters
  - (2) gauges
  - (3) Temperature gauge
    - (a) instrument voltage regulators
  - (4) electric speedometers & tachometer

#### 3. Basic Use of Diagnostic Equipment/Tools

- a. Describe diagnostic equipment used to measure voltage, current, resistance & impedance
  - (1) Interpretation of oscilloscopes
  - (2) Proper diagnostic equipment/meter connections
    - (a) Voltmeter
    - (b) Ammeter
    - (c) Ohmmeter
- b. Evaluate quality and application of diagnostic equipment
  - (1) Applications of DVOM(DMM)
  - (2) Applications of load testers
  - (3) Applications of analog meters
  - (4) Diagnostic equipment usage
    - (a) Testing diodes
  - (5) Inductive ammeters
  - (6) Meter Impedance

#### 4. Vehicle Batteries-Describe or Identify:

- a. Battery construction and performance
  - (1) Safety-jump starting
  - (2) Components
    - (a) spark arrester
  - (3) Purpose-types-construction
    - (a) lead-acid
  - (4) Define a battery
  - (5) Causes of battery failure
- b. How to evaluate battery requirements
  - (1) Reserve capacity
  - (2) C.C.A./C.A.
    - (a) Battery cold cranking rating
  - (3) BCI group identification
    - (4) Operating temperature
    - (5) Battery pack combinations
- c. Proper battery maintenance procedures
  - (1) Types of chargers
  - (2) Charging rates
  - (3) Battery maintenance
- d. Proper battery testing procedures
  - (1) Replacement
  - (2) Load Testing
  - (3) Conductivity testing
  - (4) Define surface charge
  - (5) Determine state of charge w/DMM

**5. Starting Systems -- Understand the construction and operation of starting system components**

- a. Describe starting system construction and operation
  - (1) Circuit component
  - (2) Mechanical components
    - (I) Starter solenoid
  - (3) Preventing starter motor over-speed
  - (4) Field winding types
  - (5) Pull in & hold in coils
- b. Proper cranking system & component testing procedure
  - (1) Wiring and connections
  - (2) Mechanical components/drive pinions
  - (3) Current draw
  - (4) Slow cranking engine
    - (I) Voltage drop
  - (5) Starter activation circuits
- c. Identify proper repair procedures
  - (1) Connections
  - (2) Solenoid switch contact
  - (3) Starter interlock system
  - (4) Armatures

**6. Charging Systems--Understand construction and operation of the charging system and components**

- a. Alternator construction and operation
  - (1) Function of components
    - (a) Alternator capacitor
    - (b) Voltage regulator
  - (2) Alternator output/operation
  - (3) Alternator Design
  - (4) Component recognition
    - (a) Stator
  - (5) Drive requirements
  - (6) Noise suppression
- b. Alternator & Regulator diagnosis and testing
  - (1) Unit testing
  - (2) Component testing
  - (3) On vehicle/off vehicle testing
    - (a) Undercharge/overcharge condition
  - (4) Battery isolator/isolated systems
  - (5) Mounting hardware
  - (6) Regulator adjustment procedure
  - (7) Belt tension and wrap
  - (8) Maintenance Free vs. Low Maintenance batteries
    - (a) charge voltage
- c. Proper repair procedures
  - (1) Component failures
  - (2) Replacement of regulators and remote rectifier
  - (3) Alternator failures
- d. Evaluate charging system requirements
  - (1) Load analysis
  - (2) Cable size
  - (3) Set output requirements

**7. Troubleshooting --Understand accepted practices used to diagnose and repair electrical circuits.**

- a. Analyzing results
  - (1) Interpretation of functional drawing reading
  - (2) Circuit wiring/connection
  - (3) Current draw
- b. Components
  - (1) Relays/solenoids
  - (2) Interlocks & Interfaces
  - (3) Switches & proximity
  - (4) Load managers
  - (5) Sequencer
  - (6) Proper ground connections
  - (7) Terminals
  - (8) Gauges
- c. Tools and equipment
  - (1) DVOM/DMM
  - (2) Induction meters
  - (3) load tests
- d. Diagnostic tests
  - (1) Voltage drop

**8. NFPA 1911-Chapters 3, 6, 8, 13, 17, 22**

- a. Low Voltage Electrical Systems
  - (1) Inspection and Maintenance
    - (a) Automatic electrical load management systems
  - (2) Performance Testing
    - (a) Battery testing
    - (b) Alternator testing
      - (I) Parameters
      - (II) Electrical load
    - (c) Total continuous electrical load test
      - (I) Load Shedding
    - (d) Solenoid and Relay Test
      - (I) Voltage drop maximum
    - (e) Conductivity Test
    - (f) Starter wiring test
    - (g) Regulator test
    - (h) Voltage Drop Spec's
    - (i) Lighting Tests
    - (j) On Board Battery Charger/Conditioner Test
  - (3) Out of Service Criteria
- b. Line Voltage Electrical Systems
  - (1) Inspection and Maintenance
  - (2) Performance Testing
  - (3) Out of Service Criteria
  - (4) Power Source Testing
    - (a) Receptacle wiring