



Electrical Systems A (2020)

Course Plan

Course Details

Certification:	Emergency Vehicle Technician 1
CTS Guide:	Emergency Vehicle Technician (2020)
Description:	This course provides an overview of the knowledge and skills needed to inspect and maintain low-voltage electrical systems in emergency vehicles
Designed For:	The emergency vehicle technicians pursuing SFT certification or anyone seeking an overview of low-voltage electrical systems
Prerequisites:	None
Standard:	Complete all activities and formative tests Complete all summative tests with a minimum score of 80%
Hours:	Lecture: 26:00 Activities: 8:00 Testing: 2:00
Hours (Total):	36:00
Maximum Class Size:	25
Instructor Level:	Primary
Instructor/Student Ratio:	1:25
Restrictions:	Increasing class size requires an additional qualified instructor
SFT Designation:	CFSTES

Required Resources

Instructor Resources

To teach this course, instructors need:

- *Medium/Heavy Duty Truck Electricity and Electronics* (1st edition)
 - Classroom manual and shop manual
 - Author: Sulev Oun
 - ISBN 13: 978-0827370067
 - One copy of each item per student + a personal copy for the instructor
- Student Supplement
 - Provided by California Fire Mechanics Academy, Inc.
- Personal protective equipment (PPE)
- Items from the tools and test, calibration, and diagnostic equipment listed in Topic 2-1, ELO 4 (as many as possible)

Online Instructor Resources

The following instructor resources are available online at

<https://osfm.fire.ca.gov/divisions/state-fire-training/cfstes-professional-certification/>:

- None

Student Resources

To participate in this course, students need:

- *Medium/Heavy Duty Truck Electricity and Electronics* (1st edition)
 - Classroom manual and shop manual
 - Author: Sulev Oun
 - ISBN 13: 978-0827370067
 - Provided by instructor for in-class use
- Student Supplement
 - Provided by California Fire Mechanics Academy, Inc.
- Personal protective equipment (PPE)
 - Student must bring to class
- Digital multimeter (DVOM)
 - Student must bring to class

Facilities, Equipment, and Personnel

The following facilities, equipment, or personnel are required to deliver this course:

Facilities

- Standard classroom equipped for 25 students
- Projector with appropriate laptop connections
- Wifi/Internet access

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- Outdoor space for emergency response vehicle with a clear perimeter for student activities

Equipment

- Emergency response vehicle
- One circuit training station per student that includes:
 - Battery/power supply (12 volt)
 - Lights (LED and incandescent)
 - Connectors
 - Wires
 - Fuse
 - Fuse holder
 - Circuit breaker
 - Switches
 - Relays
- Working alternator model
- Working starter model
- Fuse replacement ammeter
- Belt tension gauge
- Schematics
 - Digital or physical
 - Must correspond to an onsite emergency response vehicle
 - Five needed for Topic 2-1 activity
- Ammeter
 - Five needed for Topic 2-1 activity
- Baseline voltage checklist
 - Five needed for Topic 2-1 activity
- Solenoids
 - Intermittent and continuous duty
 - Five needed for Topic 2-1 activity
- Inspection checklist
 - Five copies for Topic 3-1 activity
- Service repair document
 - Five copies for Topic 3-1 activity

Unit 1: Introduction

Topic 1-1: Orientation and Administration

Terminal Learning Objective

At the end of this topic, a student will be able to identify facility and classroom requirements and identify course objectives, events, requirements, assignments, activities, resources, evaluation methods, and participation requirements in the course syllabus.

Enabling Learning Objectives

1. Identify facility requirements
 - Restroom locations
 - Food locations
 - Smoking locations
 - Emergency procedures
2. Identify classroom requirements
 - Start and end times
 - Breaks
 - Electronic device policies
 - Special needs and accommodations
 - Other requirements as applicable
3. Review course syllabus
 - Course objectives
 - Calendar of events
 - Course requirements
 - Student evaluation process
 - Assignments
 - Activities
 - Required student resources
 - Class participation requirements

Discussion Questions

1. What is a formative test? What is a summative test?

Activities

1. To be determined by the instructor.

Topic 1-2: Emergency Vehicle Technician Certification Process

Terminal Learning Objective

At the end of this topic, a student will be able to identify different levels in the Emergency Vehicle Technician certification track, the courses and requirements for State Fire Training (SFT) Emergency Vehicle Technician (EVT) certification, and can describe the task book and testing process.

Enabling Learning Objectives

1. Identify the different levels of certification in the Emergency Vehicle Technician (EVT) certification track

Emergency Vehicle Technician 1B

- EVT 1
 - EVT 2
 - EVT 3
2. Identify the SFT courses required for EVT 1
 - State Fire Training
 - Emergency Vehicle Technician 1A: Chassis, Cab, Body, Tank and Accessories (2020)
 - Emergency Vehicle Technician 1B: Electrical Systems A (2020)
 - Emergency Vehicle Technician 1C: Pumps and Accessories (2020)
 3. Identify the SFT courses required for EVT 2
 - State Fire Training
 - Emergency Vehicle Technician 2A: Electrical Systems B (2020)
 4. Identify the SFT courses required for EVT 3
 - State Fire Training
 - Emergency Vehicle Technician 3A: Human Resource Management / Fleet Specifications and Records (2020)
 5. Identify additional requirements for Emergency Vehicle Technician 1
 - Experience (one of the following)
 - Have a minimum of two (2) years full-time, paid experience in a California fire department, public agency, or private industry as an automotive or truck mechanic, with one (1) year of which must be related to the maintenance of emergency response vehicles; or
 - Have a minimum of three (3) years full-time, paid experience in a California fire department, public agency, or private industry as a truck mechanic with no emergency response vehicles required; or
 - Have a minimum of four (4) years volunteer time or paid part-time, paid experience in a California fire department, public agency, or private industry as a truck mechanic with primary duties performing as a truck mechanic.
 6. Identify additional requirements for Emergency Vehicle Technician 2
 - Experience (one of the following)
 - Have a minimum of three (3) years full-time, paid experience in a California fire department, public agency, or private industry as an automotive or truck mechanic, with one (1) year of which must be related to the maintenance of emergency response vehicles; or
 - Have a minimum of four (4) years full-time, paid experience in a California fire department, public agency, or private industry as a truck mechanic with no emergency response vehicles required; or
 - Have a minimum of five (5) years volunteer time or paid part-time, paid experience in a California fire department, public agency, or private industry as a truck mechanic with primary duties performing as a truck mechanic.
 7. Identify additional requirements for Emergency Vehicle Technician 3
 - Have a minimum of four (4) years full-time, paid experience in a California fire department, public agency, or private industry as an automotive or truck

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- mechanic, with one (1) year of which must be related to the maintenance of emergency response vehicles; or
 - Have a minimum of five (5) years full-time, paid experience in a California fire department, public agency, or private industry as a truck mechanic with no emergency response vehicles required; or
 - Have a minimum of six (6) years volunteer time or paid part-time, paid experience in a California fire department, public agency, or private industry as a truck mechanic with primary duties performing as a truck mechanic.
- 8. The following requirements are required for each EVT 1, EVT 2, and EVT 3
 - Code of Federal Regulations (CFR) 396.25: Department of Transportation Brake Inspector Qualification
 - Successful completion of the CFMA Certification Exam or CFMA Recertification Exam for the respective SFT Level of Certification. This exam is administered by the California Fire Mechanics Academy (CFMA).
 - EVT 1 Requires the following ASE Certifications:
National Institute for Auto Service Excellence (ASE)
 - Gasoline Engines [T1]
 - Diesel Engines [T2]
 - Drive Train [T3]
 - Brakes [T4]
 - Suspension and Steering [T5]
 - Preventative Maintenance Inspections [T8]
 - EVT 2 and EVT 3 Requires the following ASE Certifications:
National Institute for Auto Service Excellence (ASE)
 - Gasoline Engines (T1)
 - Diesel Engines (T2)
 - Drive Train (T3)
 - Brakes (T4)
 - Suspension and Steering (T5)
 - Electrical / Electronic Systems (T6)
 - Heating, Ventilation and Air Conditioning (HVAC) (T7)
 - Preventative Maintenance Inspections (T8)
- 9. Describe the task book process
 - Complete all prerequisites and course work
 - Complete all job performance requirements included in the task book
 - Must have identified evaluator verify individual task completion via signature
 - Submit application and fees
 - A candidate may apply for the EVT 1, EVT 2, and EVT 3 task books at the same time (three applications and three fees)
 - Shall not submit the EVT 2 task book until he or she receives EVT 1 certification (a prerequisite for EVT 2)
 - Shall not submit the EVT 3 task book until he or she receives EVT 2 certification (a prerequisite for EVT 3)

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- Must have Fire Chief or authorized representative verify task book completion via signature
- Must be employed by a California Fire Agency or be in a position as a volunteer or paid part-time, in a California fire department, or public agency, or private industry as a truck mechanic with primary duties performing as a truck mechanic as noted above for experience.
- This experience must be documented prior to submitting completed task book to State Fire Training

10. Complete Continuing Education

- Persons with EVT Certification are required to renew their certification every five years. The recertification requires that the applicant completes 36 hours of approved continuing education (CE) and meet all prerequisites stated for Recertification Requirements. All recertification applications must be postmarked on or before the certification expiration date. If the certified EVT did not meet all recertification requirements by the expiration date, the EVT Certification is considered to be lapsed.
- If the EVT Certification lapsed, the applicant will be required to complete 36 hours of CE in addition to the completion of additional CE hours. If the certification lapsed less than 6 months, you can regain EVT Certification by completing an additional 8 hours of approved CE. If the certification lapsed between 6 months and less than 12 months, you can regain EVT Certification by completing an additional 16 hours of approved CE. If the certification lapsed between 12 months and less than 18 months, you can regain EVT Certification by completing an additional 24 hours of approved CE.
- For expiration, greater than 18 months, the applicant will need to reapply for initial EVT 1 certification which includes successful completion of the EVT certification exam and completion of a new Certification Task Book.

11. Complete all formative and summative tests administered during the course deliveries

Discussion Questions

1. To be determined by the instructor

Activities

1. To be determined by the instructor

Instructor Notes

1. SFT teaches most EVT 1 (inspect and maintain) and EVT 2 (repair and replace) content together because depending on the size of the agency or shop, there are different expectations of the technician.

Unit 2: Inspection

Topic 2-1: Inspecting Low-voltage Electrical Systems

Terminal Learning Objective

At the end of this topic, a student, given an emergency response vehicle, SOPs, manufacturer specifications, tools, test, calibration, and diagnostic equipment, including a belt tension gauge and a digital multimeter (DVOM), schematics, an assignment, and an inspection checklist, will be able to inspect the low-voltage electrical system so that the mounting security is verified; operation and condition of the low-voltage electrical system is verified to be within manufacturer specifications; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction (AHJ)

Enabling Learning Objectives

1. Describe the principles of magnetism
 - Magnetic fields
 - Impacts of magnetic fields
2. Describe the principles of electricity
 - Kirchhoff's laws
 - Watt's law
 - Ohm's law
 - Series and parallel circuits
3. Describe the principles of circuit analysis
 - Difference in potential (flowing vs. not flowing)
 - Application of Kirchhoff's laws
 - Application of Ohm's law
 - Application of Watt's law
 - Parasitic drain
4. Describe how to select test, calibration, and diagnostic equipment
 - Digital voltmeter (DVOM)
 - Ammeter
 - Inductive
 - Low amperage (< 100 A)
 - High amperage (</= 1,000 A)
 - Series
 - Shunt or direct wire
 - Fuse replacement ammeter
 - Battery testers
 - Carbon pile
 - Conductance / battery impedance testers
 - Power probes / powered test lights
 - Benefits

Emergency Vehicle Technician 1B

- Ability to power a device
 - Ease of use
 - Problems
 - Excess voltage to computer circuits
 - Piercing
- Test lights
 - Benefits
 - Ease of use
 - Very fast
 - Problems
 - Overloading sensitive electronics
 - Trigger low amperage devices
 - Piercing
 - No accurate readings
 - Safety
 - Understand impacts of misuse (energizing relays, etc.)
- Test leads
 - Quality is critical
 - Various lengths and sizes
 - Coiled or extendable
 - Auxiliary meter leads
- Digital storage oscilloscopes (DSO)
- Scanners
 - Code readers
 - Manufacture specific
 - Bi-directional
 - Laptop with interface
- Relay substitution device
- Soldering equipment
 - 100W (medium sized electrical, base wiring, lighting systems, etc.)
 - Temperature controlled (< 25W) (circuit boards, power distribution systems, computers, etc.)
 - Battery powered
 - Torch (propane, mapp, etc.)
 - Rosin-core solder
- Crimping equipment
 - Correct crimper for device
 - Manufacturer specific
 - Hydraulic
 - Manual ratcheting
- Remote start switches
 - Safety concerns during use
- Remote power supplies

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- Battery chargers
 - Jump batteries (traditional and lightweight)
 - Bench test power supplies (adjustable current and voltage)
 - Auxiliary electronic control module/unit (ECM / ECU) power supply
 - Wire strippers
5. Use test, calibration, and diagnostic equipment
 6. Describe the function, construction, operation, and requirements of starting systems
 - Starter converts electrical energy into mechanical energy to start the engine
 - Starter must meet engine manufacturer performance standard
 7. Describe the function, construction, operation, and requirements of charging systems
 - Alternator converts mechanical energy into electrical energy
 - Alternator (and all associated systems) must meet vehicle requirements
 8. Describe the function, construction, operation, and requirements of chassis electrical components
 - Components include relays, solenoids (intermittent vs. continuous duty), wiring, modules, nodes, sensors, circuit protection devices, power distribution modules
 - Chassis electrical components must meet electrical load requirements and manufacturer specifications
 - High-voltage safety concerns (i.e. injector drivers, hybrid vehicles)
 9. Describe the function, construction, operation, and requirements of lighting systems (chassis, emergency, and accessory)
 - Components include relays, solenoids (intermittent vs. continuous duty), wiring, modules, nodes, sensors, circuit protection devices, power distribution modules, controls
 - Lighting system components must meet electrical load requirements and manufacturer specifications
 - High-voltage safety concerns
 - Strobe lights
 - High-intensity discharge (HID)
 10. List types of defects, deficiencies, and potential problems associated with low-voltage electrical systems
 - Open circuit
 - Short to power
 - Short to ground
 - Cross short
 - Excessive resistance
 11. Determine defects and deficiencies
 - Troubleshooting
 - Design deficiencies
 12. Describe how to read and interpret schematics
 - Basic schematic symbols
 - Manufacturer-specific schematic symbols
 - As-built schematics (per vehicle)

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13. Read and interpret schematics
14. Identify mounting and adjustment requirements
15. Recognize and identify potential failure symptoms and conditions of low-voltage electrical systems
 - Hard or noisy starting
 - Smoke (sight or smell)
 - Excess heat (on contact or evidenced by melting, warping, discolor, etc.)
 - Improper charging (too high or too low)
 - Failure to function
 - Onboard instrumentation readings outside parameters
 - Operator error
 - Arcing and sparking
16. Describe the inspection procedures of the manufacturer and the AHJ
 - Gather tools and safety equipment
 - Secure vehicle in a safe environment
 - Set parking brake
 - Place wheel chocks
 - Inspect low-voltage electrical system
 - Recognize and identify symptoms and conditions
 - Determine defects, deficiencies, and potential problems
 - Determine impact if not corrected
 - Complete manufacturer and AHJ inspection checklist
 - Perform operational tests
 - Complete checklist and inspection documentation
 - Release vehicle for in-service use or maintenance/repair
17. Recognize and identify symptoms and conditions
18. Determine defects, deficiencies, and potential problems
19. Perform operational checks
20. Identify record-keeping requirements
21. Complete checklist and inspection documentation

Discussion Questions

1. What do you know about voltage drop?
 - What are some causes of voltage drop?
 - What impact does voltage drop have on a circuit (or vehicle)?
 - What is an acceptable voltage drop level?
2. What problems can using the wrong test equipment create?
3. Where in the electrical system do you need to address high-voltage safety concerns?
 - What are those concerns?

Activities

1. Given an emergency apparatus and its corresponding electrical schematic, have students:
 - Identify and describe at least one circuit on the apparatus and its component relationships on the schematic

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- Select a component or device on the apparatus and locate it on the schematic
2. Given an emergency apparatus, a voltmeter, and an inductive ammeter, have students:
 - Determine proper charging system voltage and amperage
 - Measure power side and ground side voltage drops and document results
3. Given a baseline checklist, have students:
 - Compare baseline checklist data with Activity 2 data
 - Diagnose and document any potential problems
4. Given solenoids, have students:
 - Determine whether they are intermittent or continuous duty
 - Describe the mounting position of the solenoids

Instructor Notes

1. ELO 4: Use ELO 4 as a way to demonstrate the laws taught in ELO 2 and 3.
2. ELO 4: All items must be covered. Demonstrate as many as possible, bringing the equipment to the class.
3. ELO 5: Teach students when and how to use the equipment identified in ELO 4.

CTS Guide Reference: CTS 4-1

Unit 3: Maintenance

Topic 3-1: Maintaining Low-voltage Electrical Systems

Terminal Learning Objective

At the end of this topic, a student, given an emergency response vehicle, manufacturer specifications, a maintenance schedule or assignment, a maintenance checklist, SOPs, test, calibration, and diagnostic equipment, and tools, will be able to perform maintenance on the low-voltage electrical system so that deformed, broken, loose, worn, or missing parts are repaired or replaced; the operational condition is preserved or restored; calibration and adjustments are performed; activities are documented; and additional repair needs are reported

Enabling Learning Objectives

1. Describe troubleshooting and adjustment methods and procedures
 - Dead battery
 - Replace
 - Charge
 - Corrosion
 - Clean
 - Correct cause (if possible)
 - Recoat or repaint (if necessary)
 - Faulty connections
 - Clean
 - Tighten
 - Rewire
 - Replace

Emergency Vehicle Technician 1B

- Low or high voltage
 - Adjust
 - Replace
 - Rebuild
 - Send for repair
 - Deformed, broken, loose, worn, missing, or failed components
 - Tighten
 - Replace
 - Adjust
 - Send for repair
4. Evaluate reported conditions
 5. Use test, calibration, and diagnostic equipment
 6. Perform operational checks
 7. Perform all required maintenance, including all items on a maintenance checklist
 8. Correct deficiencies
 9. Complete required documentation

Discussion Questions

1. What tools and information are needed to perform a proper alternator output test?
2. What are the advantages and disadvantages of using the following circuit protection devices:
 - Fuses
 - Fusible links
 - Circuit breakers
 - PTC (positive temperature coefficient)
3. What would you do if:
 - One headlight is dimmer than the other?
 - The starter cranks slowly?
 - There is no power at all?

Activities

1. Given an inspection document, have students working in groups of up to four:
 - Evaluate reported conditions and identify the problem
 - Develop and document a maintenance plan
 - Complete repairs or correct deficiencies
 - Perform operational test of the circuit
 - Complete required documentation

Instructor Notes

1. Bring as many different pieces of test, calibration, and diagnostic equipment as possible for students to manipulate in class
2. For Activity 1, create sample scenarios for the students to resolve or have them use the inspection checklist issues identified in Topic 2-1: Activity 3

CTS Guide Reference: CTS 4-2

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Time Table

Segment	Lecture Time	Activity Time	Total Unit Time
Unit 1: Introduction			
Topic 1-1: Orientation and Administration			
Lecture	0:30		
Activity 1-1: Determined by instructor		0:00	
Topic 1-2: Emergency Vehicle Technician Certification Process			
Lecture	0:30		
Activity 1-2: Determined by instructor		0:00	
Unit 1 Totals	1:00	0:00	1:00
Unit 2: Inspection			
Topic 2-1: Inspecting Low-voltage Electrical Systems			
Lecture			
ELO 1	1:00		
ELO 2	1:00		
ELO 3	1:00		
ELO 4	6:00		
ELO 6	1:00		
ELO 7	1:00		
ELO 8	2:00		
ELO 9	2:00		
ELO 10	2:00		
ELO 11	2:00		
ELO 12	1:00		
ELO 14	0:30		
ELO 15	2:00		
ELO 16	0:30		
Activities		4:00	
Unit 2 Totals	23:00	4:00	27:00
Unit 3: Maintenance			
Topic 3-1: Maintaining Low-voltage Electrical Systems			
Lecture	2:00		
Activities		4:00	
Unit 3 Totals	2:00	4:00	6:00

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Lecture, Activity, and Unit Totals:	26:00	8:00	34:00
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Course Totals

Segment Type	Time
Total Lecture Time (LT)	26:00
Total Activity Time (AT)	8:00
Total Testing Time (TT)	2:00
Total Course Time	36:00