NATIONAL CENTER FOR AEROSPACE & TRANSPORTATION TECHNOLOGIES

# Aircraft Electronics Technician
# AET

# Study Guide

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# NCATT Aircraft Electronics Technician (AET) Study Guide

## DESCRIPTION

This AET Study Guide is designed to be used in preparing for the NCATT AET Certification examination. The study guide addresses each NCATT AET knowledge "Standard" and the required level of understanding for passing the AET examination. The AET examination will ask one or more questions from each of the standards areas. Use of this study guide coupled with a serious review of the references and study materials that are provided on the NCATT website (www.ncatt.org) will ensure the individual is adequately prepared to join the ranks of "Certified Aircraft Electronics Technicians".

## REFERENCES

***The Reference listing is for suggested materials and does not encompass all available references for use. Inclusion in this reference list is not indicative of an NCATT endorsement of materials.***


1. Bessette, Bruce 2012, Avionics Certification Test Study Guide Second Edition
2. Electrical/Electronic Textbook
3. FAR Handbook for Aviation Maintenance Technicians
4. Manufacturer's Avionics Installation Instruction Service Manuals
5. United States, Federal Aviation Administration. (1976). AC65-15A Airframe and Powerplant Mechanics Airframe Handbook. Washington: GPO.
6. United States, Federal Aviation Administration. (1976). AC65-9A Airframe and Powerplant Mechanics General Handbook. Washington: GPO
7. United States, Federal Aviation Administration. (1998). AC43.13 1B (With Change 1) & 2A* (With Change 2): Acceptable Methods, Techniques, and Practices: Aircraft Inspection, Repair, and Alterations. Washington: GPO. Reprinted by Jeppesen Sanderson Training Products. *As of 03/03/2008, 2A, Alterations, is revised to 2B
8. www.ncatt.org/pages/resources

# NCATT Level Definitions

| | Scale | Definition: The Individual |
|---|---|---|
| | | |
| Task Performance Levels | 1 | **IS EXTREMELY LIMITED**. (Can do simple parts of the task. |
| | 2 | **IS PARTIALLY PROFICIENT**. (Can do most parts of the task. |
| | 3 | **IS COMPETENT.** (Can do all parts of the task. Needs only a |
| | 4 | **IS HIGHLY PROFICIENT.** (Can do the complete task quickly |
| | | |
| Task Knowledge Levels | a | **KNOWS NOMENCLATURE.** (Can name parts, tools, and simple facts about the task.) |
| | b | **KNOWS PROCEDURES.** (Can determine step-by-step procedures for doing the task.) |
| | c | **KNOWS OPERATING PRINCIPLES**. (Can identify why and when the task must be done and why each step is needed.) |
| | d | **KNOWS ADVANCED THEORY.** (Can predict, isolate, and resolve problems about the task.) |
| | | |
| *Subject Knowledge Levels | A | **KNOWS FACTS.** (Can identify basic facts and terms about the |
| | B | **KNOWS PRINCIPLE.** (Can identify relationship of basic facts |
| | C | **KNOWS ANALYSIS.** (Can analyze facts and principles and |
| | D | **KNOWS EVALUATION.** (Can evaluate conditions and make |

**Explanations**

A task knowledge scale value may be used alone or with a task performance scale value to define a level of knowledge for a specific task. (Example: b and 1b)

*A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a subject common to several tasks.

# NCATT Aircraft Electronics Technician (AET) Study Guide

## I. Introductory and General Requirements

## II. Common Maintenance Practices

## III. Fundamentals of On Equipment Maintenance

## IV. Aircraft Fundamentals

There are thirty- four basic fundamental *Subject Knowledge, Task Performance and Task Knowledge* activities and functions within the NCATT Standard for an Aircraft Electronics Technician (AET). The AET Standard was identified and defined by aerospace industry Subject-Matter-Experts (SMEs) through an NCATT facilitated, industry recognized, occupational analysis workshop. NCATT workshops focus on the "job" a technician performs in relation to an identified topic or career field.

The NCATT AET *Standard* can be used by Aerospace Industry education and training entities to develop lesson plans as part of a complete education and training program focused on Aircraft Electronics Technicians. They can also be used to develop specialized and/or targeted AET education and training needs.
Individuals can use this document in preparation to challenge the related endorsement exam(s) by using it as a guide to find relevant materials during the study process.

# I. Introductory and General Requirements

## 1. Direct Current (DC) Basic Terms
**NCATT Level A**

Outcome: A successful education or training outcome for this subject will produce an individual who can identify basic facts and terms about "Direct Current" (DC) Basic Terms. The following is a minimum list of basic terms associated with this subject.

- Ampere (A, amp, amperage)
  - Unit of measurement used to express the flow of electrons (electrical current)
  - One ampere is a rate of flow of one coulomb (6.28 billion - billion electrons) passing a given point in an electrical circuit per second
  - In mathematical problems amperage is expressed by the letter "I"
- Battery
  - A device consisting of a number of primary voltaic cells (cells that cannot be recharged) or secondary cells (cells that can be recharged) connected in series to obtain a desired DC voltage
  - A battery stores chemical energy and makes the energy available in the electrical form
  - Aircraft storage batteries are generally rated at 12 or 24 volts
- Capacitor
  - Electrical component used to store electrical energy in the form of an electrostatic field
  - A capacitor is a device made of two parallel conductors separated by an insulator
- Conductor
  - Common building block of electrical circuits that easily permits the movement of electrons from an electrical source to a load and back to the electrical source with a minimum of resistance
  - A conductor's resistance depends on such factors as cross sectional area, length, temperature, and conductor material
- Coulomb
  - Basic unit of electrical quantity
  - A coulomb is equal to 6.28 billion - billion electrons (6.28 X 10 to the 18th)
- Current
  - The flow of electrons through a conductor is known as current flow
  - The rate of current flow is measured in amperes
- Direct Current
  - Flow of electrons in one direction throughout a circuit with constant voltage and current
  - Direct current is caused by a constant difference of potential, both negative and positive

- Electron
    - Negatively charged subatomic particles that are located and travel around (orbit) the nucleus in an imaginary sphere or shell at the speed of light (186,000 miles/second)
    - Electrons are involved in the conduction of electricity
- E.M.F.
    - The force that causes electrons to flow through a conductor
    - This force is abbreviated e.m.f.
    - The unit of measurement for electromotive force is the volt
    - In mathematical problems voltage is expressed by the letter "E"
- Farad
    - Basic unit of capacitance
    - One farad holds one coulomb under a pressure of one volt
- Henry (H)
    - Basic unit of measurement for inductance of an electrical coil
    - One (1) henry is the inductance of a coil when a change of current of one (1) ampere per second induces an e.m.f. of one (1) volt
    - In mathematical problems inductance is expressed by the symbol "L"
- Inductor
    - Coil or other device used to introduce inductance into a circuit
    - An inductor is a winding, or coiling, of multiple turns of wire
- Insulator
    - Material or device used to prevent the passage of heat, electricity, or sound from one medium to another
- Left-hand Rule
    - Refers to electrical generators
    - This rule is for determining the direction of movement of a current-carrying conductor in a magnetic field
- Magnetic Permeability
    - Measure of ease that lines of flux travel through a material
- Magnetism
    - Ability of a magnet to attract certain materials containing iron and to influence electrons
    - Magnetism is the principal way to effectively produce AC electricity
- Metric Prefixes
    - Measurements relating or using the metric system of measurement
- Neutron
    - Neutral subatomic particles that exist within the nucleus of all atoms
    - Neutrons are not involved in the conduction of electricity
- Ohm (Ω)
    - Unit of electrical opposition to the flow of current

  - A circuit has one ohm of resistance when it limits the flow of current to one amp under a voltage pressure of one volt
- Ohm's Law
  - Ohm's Law states that "the amount of current flowing in a circuit is directly proportional to the circuit voltage and inversely proportional to the circuit resistance"
  - A plain language statement for Ohm's Law is; One (1) volt causes One (1) ampere to flow through a resistance of One (1) ohm.
- Proton
  - Positively charged subatomic particles that exist within the nucleus of all atoms
  - Protons are not involved in the conduction of electricity
- Resistance (R)
  - Electrical characteristic of a conductor
  - Opposition that a circuit, component, or substance presents to the flow of electricity
  - Resistance is the force that opposes or slows down another force, drops voltage, and consumes power
  - Resistance is measured in ohms
  - In mathematical problems ohms of resistance is expressed by the symbol "R"
- Scientific Notation
  - Short way of expressing a given number as a number between 1 and 10 multiplied by 10 to the appropriate power
- Static Electricity
  - Electrical charge that may be built up on a non-conductive surface by friction
  - Static electricity serves no useful purpose
- Volt (V)
  - Basic unit of electrical pressure
  - A volt is the amount of force required to cause one amp of current to flow through one ohm or resistance
  - Volt is often expressed by such terms as voltage, voltage drop, potential difference, EMF, or IR drop
- Watts (W)
  - Basic unit of power that is the product of voltage multiplied by current
  - One watt is the power produced in a circuit that has one amp of current flowing under a pressure of one volt
- Working Voltage
  - Maximum amount of DC voltage that can be safely applied across a capacitor

## 2. Alternating Current (AC) Basic Terms
### NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Alternating Current". The following is a minimum list of terms associated with this subject.

- Alternating Current
  - Flow of electrons that continuously changes its value in magnitude and periodically reverses direction (sine-wave)
  - Alternating current is much easier to produce in large quantities as compared to DC. The time required for one cycle of AC to occur is called the period
- Apparent Power
  - Product of effective voltage and effective current which is expressed in Volt Amps (VA) rather than Watts (W) without reference to phase shift, if any, between voltage and current
- Capacitive Reactance (XC)
  - Opposition to current flow in a circuit
  - The affect that capacitance has on an AC circuit is termed capacitive reactance
  - In an AC circuit capacitance causes current to lead voltage in phase (ICE)
  - Values are given in ohms
- Delta Wound
  - Windings arranged in the shape of a triangle
  - For example, on a three- phase generator, motor, or transformer, two of the phase windings are in a series, across the third (phase) winding
- Effective Voltage
  - Amount of AC that produces the same amount of heat as a corresponding value of DC
  - The effective voltage of AC is referred to as the RMS value
  - Effective value is always less than the peak value of AC
  - Unless otherwise specified, all values of AC are considered effective values
- Frequency
  - Number of cycles of AC completed in one second
  - Frequency is expressed in hertz (Hz), 1 Hz = 1 cycle of AC/Second
  - The frequency of most AC used in aircraft applications is 400 Hz
- Impedance (Z)
  - Electrical characteristic of a conductor. Impedance is the total opposition to the flow of AC in an electrical circuit (resistance, capacitance, and inductance)
  - Values are given in ohms
- Inductive Reactance (XL)
  - Opposition to current flow in a circuit

  - The affect that inductance has on an AC circuit is termed inductive reactance
  - Inductance causes current to lag voltage in phase (ELI). Values are given in ohms
- Phase Angle
  - Angle between two similarly varying quantities (sine-waves)
  - A phase angle is the difference in angle between two sinusoidally varying quantities that have the same frequency
- Polyphase
  - Production of two or more phases of AC, or of two or more alternating voltages of the same frequency
  - The most common type of polyphase uses three phases
- Power Factor
  - Ratio of the actual power dissipated in an electrical system to the input power of volts multiplied by amps
  - The power factor is the ratio of power dissipated over input
- Rectifier
  - Electronic device that converts AC to DC
  - For example, a set of semiconductor diodes connected in a bridge circuit is a rectifier
- Resistance (R)
  - See Basic Terms/Direct Current (DC).
- Root Mean Square (RMS)
  - Effective value of sine-wave alternating current
  - The RMS value is .707 of the peak value
- Sine-Wave
  - Alternating current wave form produced by a rotary generator
  - Sine-waves are values of voltage and current that start at zero and smoothly rise to a peak value; the waves smoothly fall from a peak back to zero
  - The waves then rise to a peak value in a negative direction and smoothly return to zero
  - One AC cycle is produced by 360 degrees of rotation
- True Power
  - Power actually available in an AC circuit
  - True power is the product of the circuit voltage and the current in phase with this voltage
  - Values are given in watts
- Wye Wound
  - Windings arranged in the shape of a Y
  - For example, on a three-phase generator or transformer, one end of each of the three windings is connected to form a common point

## 3. Basic Circuit Theory of Operation
### NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Basic Circuit Theory of Operation". The following is a minimum list of terms and task associated with this subject.

- Ampere (A, amp)
  - See Basic Terms/Direct Current (DC)
- Bridge Circuits
  - Contains four impedances that form a square
  - Two diagonally opposite corners are connected to an input device
  - The other two diagonally opposite corners are connected to an output device
- Complex Circuits
  - Contains a combination of series and parallel circuits
- Joules
  - International measure of energy expended in the kilogram, meter, and second system of units
  - Also known as a Newton-meter, a Joules is the amount of work done when a force of one newton moves an object one meter along the direction of the force
- Kirchhoff's Current Law (KCL)
  - Kirchhoff's Current Law states that "the algebraic sum of the current flowing away from any point in an electrical circuit is equal to the sum of the current flowing to that point"
- Kirchhoff's Resistance Law (KRL)
  - Kirchhoff's Resistance Law states that "the total resistance in a series circuit is the sum of the individual resistances or loads in the circuit"
- Kirchhoff's Voltage Law (KVL)
  - Kirchhoff's Voltage Law states that "the algebraic sum of all of the voltage drops in any closed circuit is equal to zero"
- Ohm's Law
  - See Basic Terms/Direct Current (DC)
- Parallel Circuits
  - Contains more than one path for current
  - Circuit components are connected directly across each other
  - Current is divided between each branch in the circuit
- Power
  - Product of applied voltage and current power in a DC circuit
  - Product of applied voltage and the current in phase with the voltage in an AC circuit

- Resistance (R)
  - See Basic Terms/Direct Current (DC)
- Resistors in Parallel Circuits
  - Causes a reduction of current in multiple circuits
- Resistors in Series Circuits
  - Causes a reduction of current in one circuit
- Series Circuits
  - Contains only one path for current, making current common through all components
  - Series circuit components are connected end-to-end
- Voltage Drop
  - Reduction in voltage caused by current flowing through a resistor
  - Voltage drop is called an IR (current X resistance) drop
- Volts (V)
  - See Basic Terms/Direct Current (DC)
- Watts
  - See Basic Terms/Direct Current (DC)

## 4. Basic Circuit Troubleshooting
**NCATT Level 2b**

Outcome: A successful education or training outcome for this task/subject will produce an individual who is partially proficient in the performance task of "Basic Circuit Troubleshooting". The individual will be able to do most parts of the task and will need help only on the hardest parts. In addition, he or she will know the task procedures, and can determine the step-by-step procedures for doing the task. The following is a minimum list of terms and task associated with this subject.

**Note**: As with all troubleshooting and maintenance activities it is a good idea to keep up with the latest manufacturer's service bulletins, service instructions, service letters and FAA Airworthiness Directives (AD). Manufacture's service information is optional. Airworthiness Directives are mandatory.

Basic Troubleshooting Tools:

- Multimeter
  - Most versatile electrical measuring instrument used by aircraft technicians
  - A multimeter measures voltage, current, and resistance in an electrical circuit
  - Each multimeter has a voltmeter, ammeter, and ohmmeter which are used to analyze values in electrical circuits
  - See Perform Wire Maintenance Continuity Checks and Use Test Equipment/Special Tools

- Voltmeter
    - Used to find a circuit problem with power on the circuit
    - When checking for zero output voltage, a good starting point is to check the input with a voltmeter
- Ammeter
    - Used to find a circuit problem with power on the circuit
    - Millimeters and micro ammeters measure very small rates of current flow
- Ohmmeter
    - Used to find a circuit problem when power is removed from the circuit
    - Ohmmeters measures resistance
- Oscilloscope
    - Measures and displays voltage (AC peak-to-peak values) in waveforms (output) of a wave generating circuit
    - See Use Test Equipment/Special Tools

Basic Troubleshooting Theory:

- Continuity Check/Test
    - Checks for the existence of a complete electrical system between two points
    - Most of the time, a voltmeter or ohmmeter is used to test the continuity of a circuit
    - Tests should be made at each terminal of the circuit to isolate the problem

Steps in the Troubleshooting Process:

- Isolate the problem
    - Is the equipment being operated properly
    - Is the problem ongoing
    - Is the problem intermittent
    - Is the problem worse during taxi
    - Is the problem worse during takeoff
    - Does the problem exist while cruising
    - Is the problem worse during landing
    - Is the software loaded properly
    - What impact does weather have on the problem
- Check for the obvious
    - Are there any loose connections
    - Loose or broken wiring
    - Bent or Frayed wiring
    - Inoperative indicator lights
    - Are there bad electrical bonds
    - Broken or cracked parts
    - Anything punctured

  - Is the component over heating
  - Do some components need adjusting
- Use troubleshooting charts
  - Solve the malfunction problem, if possible, by locating the possible cause, following the isolation procedure, and making the correction (s) as shown on a troubleshooting chart
- Check manufacturer information
  - Find information on components or systems in manufacturer's installation and operations manuals or on their Website
- Perform operational checks on components or systems
  - Locate the fault through checks using a multimeter, oscilloscope, or other appropriate testing instruments or methods

Troubleshooting Circuits:

The most common problems encountered while troubleshooting circuits are the following:

- Open resistors or contacts
- Shorts between conductors

Individuals should consider how to troubleshoot the following circuits for defects using a multimeter.

- Bridge Circuits
- Complex Circuits with a Voltage Drop
- Parallel Circuits
- Resistors in Parallel Circuits
- Resistors in Series Circuits
- Series Circuits

## 5. Basic Circuit Calculations
## NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Basic Circuit Calculations". The following is a minimum list of terms associated with this subject.

AC Circuit Calculations:

- Apparent Power
  - See Basic Terms/Alternating Current (AC)
- Capacitance
  - Electrical characteristic of a conductor

    - Capacitance is the amount of electrical charge that can be stored in a capacitor under a given amount of electrical pressure (voltage)
    - Capacitance causes the current to lead the applied voltage
- Capacitive Reactance (XC)
    - See Basic Terms/Alternating Current (AC)
- Effective Value
    - Value of sine-wave alternating current needed to produce the same amount of heat as the value of the direct current
- Frequency
    - See Basic Terms/Alternating Current (AC)
- Impedance (Z)
    - See Basic Terms/Alternating Current (AC)
- Inductance
    - Electrical characteristic of a conductor. Inductance causes voltage to be produced when it is cut or crossed by lines of magnetic flux. Inductance causes the current to lag the applied voltage
- Inductive Reactance (XL)
    - See Basic Terms/Alternating Current (AC)
- Peak Voltage
    - Voltage measured from zero voltage to the maximum number of volts generated
- Period
    - Amount of time for one complete cycle of oscillation to take place
- Phase angle
    - See Basic Terms/Alternating Current (AC)
- Power Factor
    - See Basic Terms/Alternating Current (AC)
- Reactance
    - Electrical characteristic of a conductor
- Reactance is opposition to AC flow by coils and capacitors
- Values are given in ohms
- Resonance
- Electrical characteristic of a conductor
- Resonance occurs in an electrical circuit when the inductive and capacitive reactance are equal
- True Power
- See Basic Terms/Alternating Current (AC)

DC Circuit Calculations:

Mathematics is an integral part of electronics. By using formulas based on Ohm's Laws and Kirchhoff's Laws individuals can show the relationship between the following terms:

- Ampere (A, amps)
- Ohm (Ω)
- Volts (V)
- Watts (W)

## 6. DC / AC Basic Circuit Measurements
## NCATT Level 2b

Outcome: A successful education or training outcome for this task/subject will produce an individual who is partially proficient in the performance task of "DC / AC Basic Circuit Measurements". The individual will be able to do most parts of the task and will need help only on the hardest parts. In addition, he or she will know the task procedures, and can determine the step-by-step procedures for doing the task. The following is a minimum list of terms and task associated with this subject.

- Ammeters
  - Electrical testing instrument used to measure the amount of current flowing through a load
  - Values are given in amps
  - Some ammeters measure milliamps and micro amps
- Multimeter
  - Multi-function meter used to test current values, voltage values, or ohmic values (resistance)
  - A selector switch is used to set the multimeter as an ammeter, voltmeter, or ohmmeter
  - Displays on a multimeter are provided in both analog and digital format
  - Use a multimeter whenever possible
- Ohmmeters
  - Electrical testing instrument used to measure resistance in a circuit or component
  - Values are given in ohms
  - An ohmmeter provides an effective and quick way to test the condition of a switch
- Oscilloscopes
  - Electronic test instrument that displays the waveforms of electrical signals
  - Oscilloscopes measure voltages (AC peak-to-peak values), measure time to determine frequencies, and display phase relationships (comparisons of waveforms in time) to identify equipment malfunctions

- Voltmeters
  - Electrical testing instrument used to measure electrical voltage across components
  - Values are given in volts

## 7. Resistor / Color Codes
### NCATT Level A

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to determining or finding the value of a fixed resistor.

Color Codes:

- Refer to a schematic diagram where the value of the resistor is printed
- Measure the individual resistor with an ohmmeter
- Read the value (color code band) from the resistor itself, if it is legible

Optional - Use the mnemonic, "**B**ig **B**ears **R**omp **O**n **Y**ellow **G**rass **B**ut **V**iolets **G**row **W**ithout **G**etting **S**tomped **G**ood **S**tory? – "**N**ot!"

| | | | | | |
|---|---|---|---|---|---|
| BIG | Black | 0 | GROW | Gray | 8 |
| BEARS | Brown | 1 | WITHOUT | White | 9 |
| ROMP | Red | 2 | GETTING | Gold | 0.1 |
| ON | Orange | 3 | STOMPED | Silver | 0.001 |
| YELLOW | Yellow | 4 | GOOD | Gold | ± 5% |
| GRASS | Green | 5 | STORY | Silver | ± 10% |
| BUT | Blue | 6 | NOT | No Color | ± 20% |
| VIOLETS | Violet | 7 | | | |

## 8. Resistor / Fault Isolation
### NCATT Level 2b

Outcome: A successful education or training outcome for this task/subject will produce an individual who is partially proficient in the performance task of "Resistor / Fault Isolation". The individual will be able to do most parts of the task and will need help only on the hardest parts. In addition, he or she will know the task procedures, and can determine the step-by-step procedures for doing the task. The following is a minimum list of terms and task associated with this subject.

Isolate Faulty Resistors:

- Improperly Installed Resistors
  - Fault caused by resistors that are not installed correctly or installed non-compliant to industry standards

- Open Resistors
  - Fault caused by an incomplete path for current to flow from one terminal to another
  - It is possible for a resistor or fuse to open without showing any visible signs of damage
- Resistors of Incorrect Value
  - Fault caused by resistors that are outside of their specified values
- Shorted Resistors
  - Fault that allows electrical current to flow across a part of the circuit that should act as an insulator
  - Circuits with multiple components or circuit traces close together on a printed circuit board commonly have faults
  - Short circuits caused by foreign materials are common

## 9. Inductors
### NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Inductors". The following is a minimum list of terms and task associated with this subject.

Theory of Operation:

Individuals should understand the relationship of (1) current flowing through a conductor; (2) the magnetic field created around the conductor by that current flow and (3) the use of specifically designed coils of wire, known as inductors, to take advantage of these relationships. The individual should be able to explain the physical factors*, operation, and use of inductors with reference to the following terms:

- Calculation of inductive reactance
- Correct operation of inductors (coils)
- Use of multiple Inductors

Physical Factors* that affect inductance:

- Core cross-sectional area (diameter)
- Length of the coil (space between the coils)
- Number of turns of the coils
- Type of core material (permeability)

Isolate Faulty Inductors:

Individuals should be familiar with the procedures (visual and non-visual) for troubleshooting inductors, also called a coil or choke, with reference to the following terms:

- Open Inductor
  - Fault caused by an open circuit (no continuity) between the two leads. There will be no current
- Shorted Inductors
  - Fault that allows the current to travel from one lead to the other lead without going through the coil (winding) of the inductor
- Improperly Installed Inductors
  - Fault caused by inductors that are not installed correctly or installed non-compliant to industry standards

## 10. Capacitor / Theory of Operation

**NCATT Level B**

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Capacitor Theory of Operation". The following is a minimum list of terms associated with this subject.

Theory of Operation:

Individuals should be able to explain the use and operation of capacitors with reference to the following terms:

- Capacitive Reactance (XC)
  - See Basic Terms/Alternate Current (AC)
- Calculation of Capacitive Reactance
- Correct Operation of Capacitors
  - Stores electrical energy in an electrostatic field
  - The ability of a capacitor to store a charge is called capacitance
  - Capacitance offers resistance to the flow of current by continuously charging and discharging
- Dielectric
  - Insulating material that stores electrical energy in an electrostatic field
- Electrolytic Capacitors
  - Uses a liquid or paste dielectric that has a considerably higher dielectric strength as compared to air or other dry materials used as the dielectric in other capacitors
  - Electrolytic capacitors, used only in DC applications, are polarity sensitive and connecting them incorrectly in a circuit will destroy them

- Farad
  - See Basic Terms/Direct Current (DC)
- Fixed Capacitors
  - Constructed of plates and dielectrics placed firmly together and covered with a protective material such as waxed paper, plastic, ceramic material, or insulated casing
- Time Constant
  - Amount of time, measured in seconds, needed for the voltage across a capacitor to advance to 63.2% of the voltage applied to the circuit
- Uses of Multiple Capacitors
  - Reduce electrical arcing at breaker points or switch contacts
  - Reduce the emanation of electromagnetic waves in some electrical circuits
  - Allow certain frequencies in AC circuits to pass or block certain frequencies (filtering) when combined with resistors and or inductors
- Variable Capacitors
  - Changes capacitance in a circuit by changing the area of its plates
  - The dielectric in a variable capacitor is normally air
  - Variable capacitors are used in radios and other electronic devices when it is necessary to change the capacitance to meet circuit requirements

## 11. Capacitor / Fault Isolation
### NCATT Level 2b

Outcome: A successful education or training outcome for this task/subject will produce an individual who is partially proficient in the performance task of "Capacitor / Fault Isolation". The individual will be able to do most parts of the task and will need help only on the hardest parts. In addition, he or she will know the task procedures, and can determine the step-by-step procedures for doing the task. The following is a minimum list of terms and task associated with this subject.

Isolate Faulty Capacitors:

Individuals should be able to explain the procedures (visual and non-visual) for troubleshooting capacitors with reference to the following terms:

- Improperly Installed Capacitors
  - Capacitors that are not installed correctly
  - Capacitors installed non-compliant to industry standards
- Open Capacitors
  - Continuity is lost to one of the plates
  - No current in the circuit
  - Voltage applied to the circuit or branch of a circuit appears across the component that is open

- Shorted Capacitors
    - Conductive surfaces (plates) come into physical contact with each other
    - Electrical qualities of the capacitor no longer exist

## 12. Transformer / Theory of Operation

### NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Transformer Theory of Operation". The following is a minimum list of terms associated with this subject.

Theory of Operation:

- Counter EMF
    - See Basic Terms/Direct Current (DC)
- Eddy Current
    - Current loss due to heating of the core that alters the overall distribution of current flowing through the conductor
    - As the current flows, the core heats up and resistance increases due to the core positive temperature coefficient
- Hysteresis
    - Current loss due to a lag between the physical action occurring and the cause of loss
- Primary Winding
    - Input winding of a transformer connected across a power line
- Secondary Winding
    - Winding of a transformer that supplies energy to the load device
- Step-down
    - Decreases the voltage and increases the current
    - Step-down transformers have more turns in the primary coil than in the secondary coil, or winding
- Step-up
    - Increases the voltage and decreases the current
    - Step-up transformers have more turns in the secondary coil than the primary coil, or winding

Transformer classifications:

- Frequency range
- Power application
- Winding style

## 13. Transformer / Fault Isolation

### NCATT Level 2b

Outcome: A successful education or training outcome for this task/subject will produce an individual who is partially proficient in the performance task of "Transformer / Fault Isolation". The individual will be able to do most parts of the task and will need help only on the hardest parts. In addition, he or she will know the task procedures, and can determine the step-by-step procedures for doing the task. The following is a minimum list of terms and task associated with this subject.

Isolate Faulty Transformers:

Individuals should be familiar with the procedures (visual and non-visual) for troubleshooting transformers with reference to the following terms:

- Improperly Installed Transformers
  - Transformers that are not installed correctly
  - Transformers installed non-compliant to industry standards
- Open or Shorted Primary Coil
  - When the fuse or the circuit breaker (CB) in the power source is open because of excess current
- Open or Shorted Secondary Coil
  - Fault is zero volts because there is no coupling action (imperfect coupling)
- Resistance Testing
  - Breakdown of insulators or conductors of primary and secondary coils

## 14. Analog Circuits, Devices & Switches

### NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Analog Circuits, Devices and Switches". The following is a minimum list of terms and task associated with this subject.

Analog Circuits, Analog Devices, and Analog Switches:

Individuals should be able to explain the use and operation of analog circuits, devices, and switches with reference to the following terms:

- Derating Factors
  - Method for derating nominal ratings to obtain reasonable switch efficiency under reactive load conditions
- DPDT
  - Double Pole Double Throw switch

- DPST
  - Double Pole Single Throw switch
- Micro Switch
  - Precision electrical switch used to control the movement of mechanical devices
- Normally Closed
  - Relay contacts that are held closed by a spring
- Normally Open
  - Relay contacts that are held open by a spring
- Push Button Switch
  - Switch that makes contact when a button is pressed and breaks contact with the release of the button
- Relays
  - Electrically controlled device that opens and closes electrical contacts to effect the operation of other devices in the same or another electrical circuit
- Rocker Switch
  - Switch that opens and closes an electrical circuit by pushing the switch up and down with the thumb
- Rotary Switch
  - Switch capable of selecting any of several circuits
- Solenoids
  - Electro magnet device with a movable iron core that can be pulled into a coil
- SPDT
  - Single Pole Double Throw switch
- Electromechanical Switches (e.g., toggle, plunger, push-button, rocker, knob)
  - Designed for high-level loads
  - Selection based on the design or type of aircraft service needed
- Proximity Switches (Sensor-type Switches)
  - Usually solid-state devices that detect the presence of a predetermined target without physical contact
- Toggle Switch
  - Switch that is the most susceptible to shock and vibration in a plane
  - Toggle switch contacts may open momentarily, and then close

## 15. Power Supply Circuit / Rectifiers

### NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Power Supply Circuit / Rectifiers". The following is a minimum list of terms and task associated with this subject.

Rectifiers:

Individuals should be able to explain the use and operation of power supply circuit rectifiers with reference to the following terms:

- Diode
  - Simplest electrical semiconductor device formed when an N-type material is joined with a P-type material
  - Diodes are commonly used to change AC electricity into DC electricity (rectification)
  - Diodes allow current to flow in one direction only
- Forward bias
  - Semiconductor condition of operation in which a low-resistant state exists
  - On average, it takes about 0.7 VDC of the correct polarity applied to a diode to cause the diode to conduct
  - This action is known as forward biasing the diode
- Full-wave Rectifier
  - Commonly used to change AC electricity into DC electricity
- Germanium/Silicon
  - Principle semiconductor materials
  - In their pure state, germanium and silicon are insulators
  - With the addition of a small amount of dopants (impurities) to germanium or silicon, these materials are capable of carrying current and becoming semiconductors
- Half-wave Rectifier
  - Commonly used to change AC electricity into DC electricity
- Insulator
  - See Basic Terms/Direct Current (DC)
- Output DC voltage
  - One half of the input AC voltage
  - Pulsating with one half the frequency of the input AC voltage
  - The same as the input AC voltage.
- Power Supply Circuits
  - Keep the output voltage constant as the load current changes
- Reverse bias
  - Semiconductor condition of operation in which a high-resistance state exists
  - If voltage is applied in the reverse direction to a diode, the diode will not support the conduction of electricity
- Ripple amplitude
  - Frequency of a ripple in the output of a rectifier circuit
- Solid-state
  - Devices that are solid and contain no loose or moving parts

  - Semiconductor materials are often called solid-state devices
- Three-phase Rectifier
  - Commonly used to change AC electricity into DC electricity

### 16. Power Supply Circuit / Filters
**NCATT Level A**

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to power supply circuit filters.

Power Supply Circuit Filters:

Individuals should be able to explain the use and operation of power supply circuit filters with reference to the following terms:

- Active filters—Produces a current or voltage gain
- Passive filters—Produces no gain in an electrical circuit

### 17. Frequency Sensitive Filter - Theory of Operation
**NCATT Level A**

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to frequency sensitive filter theory of operation. The following is a minimum list of terms and task associated with this subject.

Theory of Operation:

Individuals should be able to explain the use and operation of frequency sensitive filters with reference to the following terms:

- Band-pass
  - Passes certain bands of middle frequencies while attenuating high and low frequencies through the use of resonant circuits
- Band-reject
  - Attenuates a certain band of middle frequencies while passing the high and low frequencies through the use of resonant circuits
- Cutoff Frequency
  - Frequency at which attenuation starts to increase rapidly
- Demodulation
  - Electronic filter that decreases the amplitude of some frequencies relative to other frequencies
- Detection
  - Another term for demodulation

- Filtering
    - Frequency-sensitive filter circuits are designed to pass a certain range of frequencies from the generator to the load device and reject all other frequencies
    - Filters are placed between the signal source (generator) and the load
    - Filters act as frequency sensitive voltage dividers
- High-pass
    - Passes high frequencies and attenuates low frequencies
- Low-pass
    - Allows low frequencies to pass from the generator to the load device and blocks, or attenuates, high frequencies
- Tuning Circuit
    - Resonant electronic circuit containing both capacitance and induction that can be adjusted to change the frequency
- Use of Crystals
    - Material used in filters to assist in the rejection of unwanted signals
    - Filters contain thin slivers of quartz crystals that vibrate at a specific resonant frequency when voltage is applied
    - Crystal (called piezoelectric crystals) can be cut and ground for various frequencies

## 18. Wave Generation Circuits

### NCATT Level A

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to wave generation circuits. The following is a minimum list of terms and task associated with this subject.

Oscillators:

Individuals should be able to explain the use and operation of wave generation oscillators with reference to the following terms:

- Crystal-controlled Oscillator
    - Electronic circuit that contains a piezoelectric crystal
    - Output frequency is determined by the resonant frequency of the piezoelectric crystal in the oscillator
    - A crystal-controlled oscillator produces a sine-wave
- Hartley Oscillator
    - Electronic circuit that uses a tapped coil in parallel with a capacitor to control the AC frequency of a circuit
- LC Tank Oscillator
    - Electronic circuit for communications receivers

    - Produces useful power at two or three times the frequency of the fundamental pulse rate
    - Stores energy alternately in the inductor and the capacitor. This storage method produces an output that is sinusoidal
- Oscillator
    - Electronic circuit that converts DC into AC at predetermined frequencies and amplitudes
    - Without the amplifier, electronic oscillation would be quickly dampened out by the resistance in the wiring of the circuit
    - The primary purpose is to generate a repetitive waveform at a constant (peak to peak) amplitude and specific frequency and to maintain this waveform within certain limits
- Regenerative Feedback Path
    - Positive feedback
    - A regenerative feedback path makes any amplifier an oscillator

Wave Shaping Circuits:

Individuals should be able to explain the use and operation of wave generation wave-shaping circuits with reference to the following terms:

- Astable Multivibrator
    - Two conditions of temporary stability and no permanent condition of stability
- Bistable Multivibrator
    - Two transistors that alternate conducting. One transistor conducts until an external pulse stops its conducting. Then, the other transistor takes over conducting
- Crystal-controlled Oscillator
    - See Wave Generation Circuits/Oscillators
- LC Tank
    - See Wave Generation Circuits/Oscillators
- Monostable Multivator
    - One permanent stable mode of operation
- Oscillator
    - See Wave Generation Circuits/Oscillators
- Transistor
    - Semiconductor devices that have three or more electrodes
    - Transistors are used for switches and amplifiers

## 19. Limiter Circuits

### NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principlesabout "Limiter Circuits". The following is a minimum list of terms and task associated with this subject.

Diodes:

Individuals should be able to explain the use and operation of limiter circuit diodes with reference to the following terms:

- Forward Bias
  - See Power Supply Circuits/Rectifiers
- Proper Use and Installation
  - Handle a device safely and properly
  - Use industry standards to install a device correctly
- Reverse Bias
  - See Power Supply Circuits/Rectifiers
- Schematic Diagram and Symbols
  - Electric or fluid power system graphical presentation
  - Components of the system are represented by symbols, not pictures or drawings
  - A schematic diagram is used mainly for troubleshooting a system or device
- Zener Diodes
  - Special application diode in which electricity is conducted under certain voltage conditions
  - The zener diode's primary purpose is to regulate voltage

Transistors:

Individuals should be able to explain the use and operation of limiter circuit transistors with reference to the following terms:

- Base Current
  - Electrode between the emitter and the collector
  - The base controls the amount of current passed
- Bipolar Transistors
  - NPN Transistor—Three-element semiconductor formed by placing a lightly doped, very thin region of P-type silicon or germanium between two regions of N-type material which affects current
  - PNP Transistor—Three-element semiconductor formed by placing a lightly doped, very thin region of N-type silicon or germanium between two regions of P-type material which affects current

    - Polarity of Connections—NPN and PNP transistors are not interchangeable because of their opposite polarities
- Collector Base Junction
    - Must be reverse-biased for a transistor to conduct current
- Collector Current
    - Electrode from which conventional current leaves the transistor
    - The collector collects the current
- Emitter Base Junction
    - Must be forward-biased for a transistor to conduct current
- Emitter Current
    - Electrode that compares with the cathode in an electron tube
    - The emitter emits the current carriers
- Junction
    - Point at which two materials are in contact with each other
- Proper Use and Installation
    - See Limiter Circuits/Diodes
- Schematic Diagram and Symbols
    - See Limiter Circuits/Diodes

## 20. Digital Numbering Systems
### NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Digital Numbering Systems". The following is a minimum list of terms and task associated with this subject.

Binary:

Individuals should be able to explain the use of the binary digital numbering system and practice conversions with reference to the following terms:

- Binary Digit (bit)
    - Each zero or one is a binary number
- Binary Numbering System (Binary Notation)
    - Mathematical computation based on powers of two
    - The binary numbering system is composed of two digits (1 and 0)
    - Binary notation operates in Base 2
    - Each digit in a binary number represents two bits
- Byte
    - Consists of eight bits
- Conversions

  - Mathematical ways to express digital numbering systems
  - A decimal number may be converted to its binary equivalent by sequentially dividing the number by 2 and recording each remainder
- Decimal Numbering System
  - Uses numbers 0 – 9
  - The decimal numbering system operates in Base 10

Octal:

Individuals should be able to explain the use of the octal digital numbering system and practice conversions with reference to the following terms:

- Conversions
  - See Digital Numbering Systems/Binary
- Octal Numbering System (Octal Notation)
  - Mathematical computation based on powers of eight
  - The octal numbering system is composed of eight digits (0 – 7)
  - Octal notation operates in Base 8
  - Each digit in an octal number represents three bits, a triad

Hexadecimal:

Individuals should be able to explain the use of the hexadecimal digital numbering system and practice conversions with reference to the following terms:

- Conversions
  - See Digital Numbering Systems/Binary
- Hexadecimal Numbering System (Hexadecimal Notation)
  - Mathematical computation based on powers of 16
  - The hexadecimal numbering system is composed of 16 units (decimal numbers 0 – 9 and letters A – F for decimal numbers 10 – 15)
  - Hexadecimal notation operates in Base 16
  - Each digit in a hexadecimal number represents four bits

## 21. Digital Logic Functions
### NCATT Level B

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows and can identify the relationship of basic facts and state general principles about "Digital Logic Functions". The following is a minimum list of terms and task associated with this subject.

Main Logic Gates:

Individuals should be able to explain the proper use, installation, and operation of main logic gates with reference to the following terms:

- AND Logic Gate
  - The AND logic gate has two or more inputs and one output
- Display of Digital Data
  - Alphanumeric characters produced by visible segments on LED or LCD devices
  - Normally, seven or less segments are used to form the numbers 0–9
- EXCLUSIVE OR Logic Gate
  - The EXCLUSIVE OR logic gate requires inputs to be different to obtain an output
- Function Table
  - Describes the electrical states
- Inverter Circuit
  - Performs the respective negator, NOT logic, function
  - An inverter has one input and one output that are always in opposition
  - An inverter is a logic device, not a gate
- Logic Gates
  - Switching circuits connected together to make a variety of digital systems
- Main Logic Gate
  - Can handle AND, OR, NOT, NOR, NAND, and EXCLUSIVE OR decisions
  - Main logic gates form logical input signals in various ways to produce the desired outputs
- NAND Logic gate
  - Means NOT AND
  - The NAND logic gate has two or more inputs and one output
  - It is usually followed by an inverter
- Negative Logic
  - The more positive (higher) voltage stands for 0; the less positive (lower) voltage stands for 1
- NOR Logic Gate
  - Means NOT OR. The NOR logic gate has two or more inputs and one output. It is usually followed by an inverter
- OR Logic Gate
  - The OR logic gate has two or more inputs and one output
- Positive Logic
  - The more positive (higher) voltage stands for 1; the less positive (lower) voltage stands for 0
- Truth Table
  - Describes the behavior of a logic gate

Flip-flops:

Individuals should be able to explain the use and operation of flip- flops with reference to the following terms:

- Asynchronous
  - Change occurs at a speed determined by circuit functions, not a timing device
- Clock Pulse
  - Pulse generator used to synchronize the timing of switching circuits
  - The clock determines when certain actions can occur in a digital system
- Data-type Latch
  - Stores the status of its "D" input whenever the clock input makes a certain transition (low to high or high to low)
  - Latch input is fed from its own inverted output
- Flip-flop
  - Bi-stable (stable in either of two alternative states) or static memory element used to store information
  - Bi-stable means one output for the normal value and one output for the complement value of a stored bit
- J-K Flip-flop
  - During clocking, the inputs and outputs toggle between 1 and 0
- Latch
  - Two cross-coupled NAND or NOR logic gates where the output of each gate is applied to the input of the other gate
  - A latch can have data input, clock input, and output
- R-S Latch
  - Two cross-coupled NOR logic gates where supplying a 1 at either input causes the output to be 0
- Synchronous
  - Change occurs at the same instant using a timing device

Counters:

Individuals should be able to explain the use and operation of counters with reference to the following terms:

- Adder-Subtractors
  - Digital circuit capable of adding or subtracting numbers in a circuit
- Counter Triggering Method
  - Output number increases by one at every pulse due to a toggling effect
- Counter
  - Memory register with special features

  - A counter is a flip-flop interconnection having an input that enables binary counting. Every time an input is received, the register changes in a regular pattern. Changes are also prearranged by the system
- Frequency Division/Divider
  - Electronic circuit that takes an input signal with a frequency and generates an output signal with a frequency
  - Frequency dividers can be implemented for both analog and digital applications
- Subtractor
  - Digital circuit that performs the subtraction of numbers
  - The most common subtractors operate on binary numbers

Adders:

Individuals should be able to explain the use and operation of adders with reference to the following terms:

- Adder
  - Digital circuit that performs the addition of numbers
  - The most common adders operate on binary numbers
- Full-adder
  - Digital circuit that performs an addition operation on three binary numbers
- Half-adder
  - Digital circuit that performs an addition operation on two binary numbers

## II. Common Maintenance Practice

### 22. Hazards / Safety Practices
**NCATT Level A**

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to common shop hazards and safety practices. The following is a minimum list of terms and task associated with this subject.

RF Energy:

There are OSHA standards, other federal standards, and national consensus standards relevant to radio frequency and microwave radiation. Individuals should be able to explain the use of RF energy, hazards, and safety programs with reference to the following terms:

- Personal Protective Equipment (PPE)
  - The use of PPEs takes into consideration key factors involved in the identification of hazards to employees (inhalation, skin absorption, ingestion, and eye or skin contact)

    - Personal Protection Equipment is material-hazard specific and takes into account the performance of PPE materials (and seams) in providing a barrier to potential hazards
- Residual Risks
    - Most RF systems have some residual risks such as high voltages, hot surfaces, and toxic materials
- RF Energy
    - Radio frequency energy/radiation. RF energy is one form of electromagnetic energy that makes up the electromagnetic spectrum
    - Radio frequencies are used for providing radar and telecommunications services and for industrial heating and sealing
- RF Protection Program
    - Includes training in normal operation of equipment, support such as periodic screening of employees and facilities, and applicable emergency procedures
- Specific Absorption Rate (SAR)
    - Common measure of exposure to RF energy

Noise:

Individuals should be able to explain noise hazards and safety programs with reference to the following terms:

- Active Hearing Protection
    - Active Noise Reduction (ANR) earmuffs, headsets, and helmets containing electronic components that enhance communications
    - These devices substantially improve intelligibility and comfort, which decreases fatigue
- Allowable Daily Exposure
    - OSHA has adopted a 90 dB (A) level limit within a daily 8- hour exposure
- Noise Protection Program
    - Includes training in normal operation of equipment, support such as periodic screening of employees and facilities, and applicable emergency procedures
- Noise
    - Refers to a sound, especially one that is noticeably unpleasant and very loud
- Passive Hearing Protection
    - Earplugs and earmuffs with low-level protection

Electrical Power:

Individuals should be able to explain the use of electrical power, hazards, and safety programs with reference to the following terms:

- Job Briefings

    - Meetings with employees involved before they start each job
    - A Job briefing covers the following subjects:
        - Hazards associated with the job
        - Work procedures involved
        - Special precautions
        - Energy source controls
        - PPE requirements
- Electrical Protective Devices
    - Protective electrical insulated gloves and sleeves or other electrical protective equipment to be worn when employees are exposed to electrical shock hazards while working on electrical equipment
- Circuit Protection Devices
    - Include fuses, current limiters, thermal protectors (switches), and circuit breakers
- Elimination/Termination of Circuit Power
    - Specific procedural steps for shutting down, isolating, blocking, and securing machines or equipment to control hazardous energy sources
    - Lockout/tagout devices are often used
    - There are also procedures for the placement, removal, and transfer of these devices
- Electrical Power Protection Program
    - Includes training in normal operation of equipment, job briefings, support of safety-related work practices, and applicable emergency procedures

ESD Protection:

Individuals should be able to explain the ESD hazards, causes, and safety programs with reference to the following terms:

- ESD
    - Electrostatic Discharge is the instantaneous discharge of static electricity that has built up on one surface or point and is discharged to another surface or point
- ESD Control Program
    - Grounded workstation surfaces and equipment
    - Personnel grounding
    - Handling precautions
    - Protective packaging for ESD items when transporting or storage
- Conductive Wrist Strap (Connected to Earth Ground)
    - Worn by an individual to keep a workstation free of static charges
- MIL-STD-129
    - ESD caution standard (military) that includes procedures for precautionary measures

- ESD Protection Program
    - Includes training in examples of ESD failures, prevention, support of safety-related work practices, and applicable emergency procedures

Microwave Energy:

Radio Frequency (RF) energy and microwave energy are forms of electromagnetic energy; they differ in frequency and wavelength. Individuals should be able to explain the terms and safety programs with reference to the following terms:

- Microwave (MW) Energy / Radiation
    - Microwave energy is one form of electromagnetic energy that makes up the electromagnetic spectrum
    - Microwave frequencies are normally used for satellite communication and radar
    - These frequencies are also used for bonding composite sheets for the automotive and aerospace industries
- Microwave Protection Program
    - Includes training in normal operation of equipment, support such as periodic screening of employees and facilities, and appropriate emergency procedures

Hazardous Liquids:

Individuals should be able to explain the importance of manufacturer's warnings and recommendations for hazardous liquid safety practices with reference to the following terms:

- Acetone
    - Organic solvent of industrial and chemical significance
    - Acetone is colorless, volatile, and extremely flammable
- Adhesives
    - Substances that adhere or bond two components, or items, together
    - Many adhesives contain flammable and toxic elements
- Caustic Solutions
    - Substances that can burn and destroy living tissues or soft metals
    - Caustic solutions are usually strong acids and/or bases
- Cleaners
    - Substances that may contain solvents, corrosives, or any number of chemicals to clean an aircraft
- Coatings
    - Substances that function to protect surfaces
    - Coatings contain pigments, paints, solvents, drying oils, and other additives
- Degreasers and Strippers
    - Substances that clean commercial and industrial parts
    - Many degreasers and strippers contain flammable and toxic elements

- Hazardous Liquids
    - Includes corrosives, ignitables, and reactives, as well as chemicals used as solvents, cleaners, caustic solutions, degreasers, strippers, adhesives, and coatings
- How to Obtain Proper Material Safety Data Sheet (MSDS) Information
    - See Hazardous Material Handling/Material Safety Data Sheet
- Solvents
    - Substance that dissolves another substance or substances to form a solution
    - Solvents are usually, but not always liquid
    - Solvents can also be gases or solids
- Methyl Ethyl Ketone (MEK)
    - Solvent used in the surface coating industry and in dewaxing of lubricating oils
    - Methyl Ethyl Ketone may be used with other solvents such as acetone, ethyl acetate, hexane, toluene, and alcohols

First Aid for Electrical Shock:

Individuals should be able to explain first aid for electrical shock with reference to the following safety precautions:

- TURN OFF THE POWER as quickly as possible
- If unable to locate the power switches, do not attempt to touch the victim. Touching the victim will pass the current through anyone who touches the victim
- If electrical power cannot be removed, use a dry wooden pole, wooden broom, or dry wooden chair to PUSH or ROLL the victim clear of the power source. Dry, non-conducting objects made of cardboard, plastic, or wood are suitable to use to remove the victim from the power source
- If clothing, belt, rope, or cord must be used, be careful to AVOID CONTACT WITH THE VICTIM! Form the rescue device into a loop, and slip the loop over the foot, leg, or arm of the victim (without touching the victim) to drag them away from the power source
- Once the victim is "free" of the power source, do not move them unless it is necessary
- Proper Steps to Take in Case of Need for First Aid—When someone needs first aid after electrical shock, follow these steps:
    - Keep the victim lying down
    - Slightly elevate their legs and feet
    - Cover the victim with a blanket to maintain body heat
    - Do not move the victim unless it is necessary
    - Seek qualified medical aid, but try not to leave the victim alone
    - If the victim needs water, give them a few sips of water at first. Then, gradually increase water intake unless nausea is present

First Aid and CPR:

- American Heart Association Guide for CPR, October 18, 2010

- Call 911 or ask someone else to do so
- Try to get the person to respond; if he doesn't, roll the person on his or her back
- Start chest compressions. Place the heel of your hand on the center of the victim's chest. Put your other hand on top of the first with your fingers interlaced
- Press down so you compress the chest at least 2 inches in adults and children and 1.5 inches in infants. "One hundred times a minute or even a little faster is optimal," (That's about the same rhythm as the beat of the Bee Gee's song "Stayin' Alive.")
- If you're been trained in CPR, you can now open the airway with a head tilt and chin lift
- Pinch closed the nose of the victim. Take a normal breath, cover the victim's mouth with yours to create an airtight seal, and then give two, one-second breaths as you watch for the chest to rise
- Continue compressions and breaths -- 30 compressions, two breaths -- until help arrives

Hazards / Safety Practices Notes:

- An employer shall ensure that each affected employee uses appropriate hand protection and other protective clothing where there is exposure to hazards such as skin absorption of harmful substances, severe cuts or lacerations, severe abrasions, punctures, chemical burns, thermal burns, harmful temperature extremes, and sharp objects. Consult federal, state, and local Hazardous Material procedures for disposal specifics
- First aid treatment for bleeding, burns, and broken bones. Never put ointments, grease, or butter on a burn. They will only have to be painfully removed once medical aid is obtained

## 23. Hazardous Materials Handling

### NCATT Level A

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to hazardous materials handling. The following is a minimum list of terms and task associated with this subject.

Handling Procedures:

Individuals should be able to explain that many materials and chemicals in the workplace are hazardous and should be handled properly with reference to the following terms:

- Required Handling Knowledge
  - How to use hazardous substance
  - Procedures to protect health and safety
  - PPE use

- Personal Protective Equipment (PPE)
    - See Hazardous Materials Handling/Types of Hazardous Materials/Fluids
- Proper Safety Equipment
    - Includes respirators, gloves, eye protection, and dust masks

Material Safety Data Sheet:

The demands for staying compliant are getting more difficult. Individuals should be able to explain the use of Material Safety Data Sheets with reference to the following terms:

- Material Safety Data Sheets (MSDS)
    - Form containing data regarding the properties of a particular substance
    - Material Safety Data Sheets provide workers and emergency personnel with procedures for handling or working with a hazardous substance in a safe manner
    - These sheets include information such as physical data (e.g., melting point, boiling point, flash point) toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill handling procedures
- MSDS Compliance/Chemical Suppliers
    - Hazardous chemical suppliers are required by law to supply MSDSs to purchasers
- MSDS Compliance/Employers
    - Employers shall maintain any MSDSs received with incoming shipments of hazardous chemicals
    - Employers shall ensure that MSDSs are readily accessible during each work shift to employees when they are in their work areas
    - This information includes new chemicals or revised MSDSs
- MSDS System
    - Cataloging information on chemicals, chemical compounds, and chemical mixtures

Proper Disposal:

Individuals should be able to explain that federal, state, and local environmental regulations require strict control of handling, storage, and disposal of all materials designated as hazardous or toxic to human health or to the environment. Individual should be able to explain the proper management and disposal of hazardous materials with reference to the following terms:

- Employer's Responsibility
    - Follow guidelines set forth by federal, state, and local government agencies and properly train employees in the handling, storage, and disposal of hazardous materials
- Environmental Protection Agency (EPA)
    - The EPA has the authority to control hazardous waste

    - EPA control includes the generation, transportation, treatment, storage, and disposal of hazardous waste
- Specifics to Follow at Jobsite
    - Never pour hazardous materials down the drain
    - The hazardous materials could cause damage to a waste water plant
    - Never pour hazardous waste down a storm drain
    - Pouring hazardous waste down a storm drain often leads directly to a lake, stream, or other body of water
    - The hazardous waste could contaminate bodies of water such as lakes or streams
    - Dispose of all solvent waste, oily rags, and flammable liquids in covered fire resistant containers until removed from worksite

Storage and Labeling:

Individuals should be able to explain proper storage and labeling procedures with reference to the following terms:

- Labels
    - Written, printed, or graphic material displayed on or affixed to containers of hazardous substances
    - Labels frequently contain other information, such as precautions
    - This information is provided voluntarily and is not required
    - All containers must be properly labeled with waterproof labels that list the following:
        - Substance name and trade name
        - Manufacturer
        - Hazards
        - Date
- Storage and Housekeeping
    - Bags, containers, and bundles shall be stacked, blocked, interlocked, and limited in height so they are stable and secure against sliding, falling, or collapse
    - Storage areas shall be kept free of accumulation of materials that constitute hazards from tripping, fire, explosion, or pest harborage
    - Incompatible substances shall be stored on different shelves or placed in non-flammable storage cabinets
    - Aisles and passage ways shall be kept clear to provide for the free and safe movement of material handling equipment and employees

Types of Hazardous Materials/Fluids:

Individuals should be able to explain that hazardous materials and fluids may be toxic, corrosive, flammable, reactive (unstable), and explosive with reference to the following terms:

- OSHA Standard 29 CFR 1910.120
    - Hazardous Waste Operations and Emergency Response OSHA standard
- Permissible Exposure Levels (PEL)
    - Allowable level for a hazardous substance in the "breathing" air in which employees are exposed
- Personal Protective Equipment (PPE)
    - Shields or isolates individuals from chemical, physical, and biologic hazards that may be encountered at a hazardous substance site
    - For example, respirators must be worn when employees are exposed to high levels of hazardous substances in the air
- Physical Health Hazards
    - Includes fires, dangerous reactions, and explosions
- Use of MSDS
    - See Hazardous Materials Handling/Material Safety Data Sheets
- Workplace Communication Programs
    - OSHA requires all employers to provide information to their employees about the hazardous materials and chemicals to which they are exposed by means of a hazard communication program
    - Workplace communications programs include labels and other forms of warning, Material Safety Data Sheets, and information and training
    - In addition, it is mandatory that distributors transmit OSHA required information to employers who purchase their products

## 24. FOD Prevention

### NCATT Level 1a

Outcome: A successful education or training outcome for this task/subject will produce an individual who is extremely limited in the performance task of "FOD Prevention". The individual will be able to do simple parts of the task. He or she will need to be told or shown how to do most of the task. In addition, he or she can name parts, tools and simple facts about the task. The following is a minimum list of terms and task associated with this subject.

Practice FOD Prevention:

Individuals should be able to explain FOD prevention and accountability with reference to the following terms:

- FOD (Foreign Object Debris)
    - Substance, debris, or article alien to a vehicle or system that has invaded the product and could cause damage
- FOD (Foreign Object Damage)
    - Any damage or incident attributed to a foreign object that can be expressed in

physical or economic terms which may or may not degrade the product's required safety and/or performance characteristics

- FOE (Foreign Object Elimination)
  - Program or process used to assure a FOD-free product/system
- Clean As You Go
  - Clean the immediate area when work cannot continue
  - Clean the immediate area when work debris has the potential to migrate to an out of sight or inaccessible area and cause damage and/or give the appearance of poor workmanship
  - Inspect and clean all tools after job completion or end of shift
  - Clean the immediate area after work is completed and prior to inspection
  - Clean at the end of each shift
  - If you drop something or hear something drop - pick it up!
- Tool Control and Management
  - Methods of tool control and accountability include shadow box/board, tether, chit system, tool inventory sheets/logs, tool pockets, tool identification, consolidated tool kits, tool conditions, sponge count, and electronic tool accountability systems
- FOD Prevention Program
  - Includes training in FOD control, management, and accountability, and support such as periodic screening of employees and facilities
  - Appropriate emergency procedures need to be followed when FOD becomes hazardous

## 25. Technical Publications

### NCATT Level A

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to the selection and use of technical publications. The following is a minimum list of terms and task associated with this subject.

Interpret Installation Manuals:

The aircraft installation and maintenance manuals are provided by the manufacturer for individuals who normally perform work on the systems or components of an aircraft. Individuals should be able to explain how to interpret installation manuals with reference to the following:

- Locate, research, and interpret technical information from manuals for installing aircraft systems
- Consult manuals for guidance when installing and maintaining aircraft systems and components. Select the most appropriate way to install or maintain the component
- Use information in manuals to correct unsafe conditions found in/on aircraft

- Consult aircraft specifications and standards to determine engine type design and limitations, as well as other important information

Additional documents to consult or refer to:

- Consult FAA Airworthiness Directives (ADs) for unsafe conditions found in aircraft engines, propellers, or appliances
    - Airworthiness Directives (Ads) also provide the timeframe for compliance
    - FAA publishes a summary of ADs every two years
    - Consult FAA document, AC 43.13-1B/2B, if no maintenance manual exists for maintaining an aircraft
    - Consult Federal Aviation Regulation 14 CFR Part 43 for regulatory requirements concerning Maintenance, Preventive Maintenance, Rebuilding, and Alterations
    - Consult Federal Aviation Regulation 14 CFR Part 65 for regulatory requirements for certified airmen (mechanic and repairman) privileges and limitations

**Interpretation Notes:** Check the Table of Contents. Check the index for subjects and details. Read the title of the chapter and headings for the main idea. Break down the whole into parts. Refer to the symbols in the legend or key on a drawing or document. Read the labels and callouts on a drawing. Scan a drawing or document to quickly find information. Compare with other types of information to see relationships. Locate terms in the glossary or an aeronautical dictionary. Search the document online or on a CD or DVD, if available.

Interpret Technical Data:

Examples of technical data include manufacturer's service bulletins, service letters, and service instructions to notify aircraft owners of design defects and product improvements. Individuals should be able to explain how to interpret technical data with reference to the following terms:

- Schematic Diagrams
    - Show an electrical or fluid power system
    - The components are represented by symbols rather than drawings or pictures of the actual devices
    - Schematic Diagrams do not necessarily show the locations of a system
    - These diagrams are used mainly for troubleshooting
- Block Diagrams
    - Shows functional units represented by blocks
    - Each block describes a function of a system and shows its relationship to other units in the system
    - The energy flow direction, or association, within the system is shown with arrows
    - Block diagrams are high level diagrams used for troubleshooting or teaching a process
- Installation Diagrams

    - Show a picture of aircraft systems, devices, and components
    - Each component relevant to a particular aircraft system is identified and located by callouts
    - Installation diagrams are used for aircraft maintenance and repair
- Wiring Diagrams
    - See Technical Publications/Wiring Diagrams
- Various Media Containing Information:
    - DVDs—High-capacity optical disk containing video recordings or data
    - Videos—Recording of a motion picture or presentation
    - Software—Programs, usually on CDs, to instruct and teach concepts
    - Microfiche—Sheet of microfilm that contains rows of images of printed matter

Locate and Interpret Avionics Installation Data:

Individuals should be able to explain how to locate and interpret avionics installation data with reference to the following terms:

- Aircraft Equipment Lists
    - See Technical Publications/Interpret Aircraft Equipment List Information
- Aircraft Maintenance Records
    - Document used for entering records of maintenance on a particular aircraft
    - FAA regulations allow this information to be kept in a database on a computer
- Aircraft Service Manuals
    - Document that cover all phases of aircraft operation from assembling the newly purchased aircraft, operating and maintaining the equipment, and storing of the equipment
- Aircraft Weight and Balance
    - Document that provides a method of determining the empty weight and empty-weight center of gravity (EWCG) of an aircraft
    - This document also furnishes the flight crew with information on loading and operating the aircraft to ensure its weight is within the allowable limit and the center of gravity (CG) is within the allowable range
- Approved Flight Manual Supplements
    - Document that supersede manufacture's initial manuals (e.g., installation manuals, maintenance manuals, Specifications, Standards)
    - Most manuals are accessible on the manufacturer's website, however, a code (password) may be needed to access the information
- Manufactures Service Bulletins
    - Document that contains a recommendation about a defect or an improvement to an aircraft
    - The bulletin may recommend a certain type of inspection, replacing certain components, performing maintenance in a specific manner, or limiting operation

    - Some bulletins may address a timeframe for the work to be completed
    - Service Information that may be identified as a service bulletin, technical service bulletin, service letter, or service instructions
    - Compliance with a service bulletin is not specifically required under the Federal Aviation Regulations (FAR) unless the service bulletin is accompanied by or includes an Airworthiness Directive (AD)
- Supplemental Type Certificates (STC)
    - Document issued by the FAA approving an Aircraft Type Design alteration (e.g., airframe, engine, propeller)

Interpret Wiring Diagrams:

Individuals should be able to explain how to interpret wiring diagrams with reference to the following:

- Wiring Diagrams
    - Show the wiring of an electrical system using standardized symbols that represent electrical components or devices
    - Wiring Diagrams show how the components (wiring, connectors, terminal boards, and other parts of a circuit) are connected together electrically
    - These diagrams are used to troubleshoot and repair electrical circuits

Interpret Charts, Blueprints, Drawings, and Sketches:

Charts, blueprints, drawings, and sketches present facts in a visual form. They help aircraft mechanics to pinpoint problems with in an aircraft. Sometimes this information needs to be compared with other types of information to see a relationship. Individuals should be able to explain how to interpret charts, blueprints, drawings, and sketches with reference to the following terms:

- Charts
    - Includes information found in manuals, bulletins, or books
- Blueprints
    - Includes detailed mechanical drawings or architectural plans for an aircraft.
- Drawings
    - See Technical Publications/Interpret Technical Data/Interpret Wiring Diagrams
- Sketches
    - Includes a rough drawing representing aircraft systems or components

Interpret Aircraft Equipment List:

Individuals should be able to explain how to interpret aircraft equipment lists with reference to the following:

- FAA Approved Minimum Equipment List
  - An FAA approved list of installed instruments or equipment that may be inoperative while allowing the aircraft to continue to be operated
  - Referred to as a Minimum Equipment List (MEL)
  - An FAA approved MEL is typically developed by a manufacturer for a specific aircraft
  - See CFR 14 Part 91.213 for details
- Standard Aircraft Equipment Lists
  - An aircraft's equipment list is a detailed listing of instruments and equipment that are installed in the aircraft
  - See CFR 14 Part 91.205 for FAA minimum requirements

## III. Fundamentals of On-Equipment Maintenance

### 26. Use Common Tools
### NCATT Level 2b

Outcome: A successful education or training outcome for this task/subject will produce an individual who is partially proficient in the performance task of "Use of Common Tools". The individual will be able to do most parts of the task and will need help only on the hardest parts. In addition, he or she will know the task procedures, and can determine the step-by-step procedures for doing the task. The following is a minimum list of common tools associated with this task.

Use Common Tools:

Individuals should be able to explain the use of common tools with reference to the following terms:

- Common Tools
  - Includes various hammers, mallets, screwdrivers, pliers, plier-type cutting tools, punches, wrenches, special wrenches such as spanner, torque, and allen, hand snips, hacksaws, chisels, files, drills, twist drills, reamers, countersinks, wire strippers, crimpers, pin extractors, magnifying glasses, engineering scales, analog and/or digital multimeters, wire-marking machine/devices, rules, combination sets, scribers, calipers, micrometer calipers, vernier scales, taps, and dies
- Proficiency
  - Able to use various tools associated with aircraft wiring including measurement tools
  - Able to distinguish that some tools can have more than one use.
  - Able to choose the tool best suited for the job

- Safety
    - Able to properly handle and care for tools, as well as follow proper safety precautions. For example, improper use of a hammer can damage an aircraft and cause physical injury

### 27. Handling Electrostatic Devices
**NCATT Level A**

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to handling electrostatic devices.

Handling of Electrostatic Devices:

Static-sensitive devices such as printed circuit boards and solid-state devices can be damaged by the electrostatic field around us. Individuals should be able to explain basic facts and handling procedures with reference to the following terms:

- Static Electricity
    - Serves little useful purpose. Static electricity is more of a nuisance
- Electrostatic Field (Sometimes called a Dielectric Field)
    - Invisible force that causes electrically-charged items to repel or attract each other
- Electrostatic Damage
    - Includes total catastrophic failure, delayed failure, and degradation to the circuit
- Proper Grounding and Handling
    - Attach wrist strap that connects body to ground
    - Touch only the components to be installed or removed
    - Drain off charges that accumulate on your body by touching the grounded metal case
    - Do not touch bare pins
    - Use conductive covers when transporting devices
    - Use electrostatic spray

### 28. Identify & Perform Corrosion Control
**NCATT Level a**

Outcome: A successful education or training outcome for this task/subject will produce an individual who knows the nomenclature used in the performance task of "Identifying and Performing Corrosion Control". In addition, he or she can name parts, tools and simple facts about the task. The following is a minimum list of terms and task associated with this subject.

Identify and Perform Corrosion Control:

Corrosion is a major contributing cause to the reduction of avionics equipment reliability. Individuals should be able to explain procedures for corrosion control in aircraft electrical and avionics systems with reference to the following terms:

- Corrosion
  - Chemical or electrochemical deterioration of a material, usually metal, due to a reaction with its environment
  - May be visible, or not visible
- Corrosion Types
  - Galvanic Corrosion occurs when different metals are in contact with each other in the presence of an electrolyte
  - Pitting Corrosion is a severe form of concentrated cell corrosion localized in a specific area containing pits usually accompanied by white or gray powder
  - Exfoliation Corrosion is an extreme form of intergranular corrosion along the grain boundaries. The strength of the metal is destroyed due to separation or poor bonding
  - Intergranular Corrosion is corrosion that forms within the metal along metal grain structures
- Causes of Corrosion
  - Moisture
  - Industrial chemicals
  - Improper maintenance procedures
  - Improper heat treatment at manufacturer
- Controlling Corrosion
  - Cooling air systems that remove moisture and particulate matter
  - Proper packaging, handling, and storage of avionics equipment and components
  - Insulation to prevent conductive paths
  - Sealants that prevent moisture and chemicals from damaging metals
  - Good housekeeping

### 29. Use Safety Devices
### NCATT Level 1a

Outcome: A successful education or training outcome for this task/subject will produce an individual who is extremely limited in the performance task of "Use of Safety Devices". The individual will be able to do simple parts of the task. He or she will need to be told or shown how to do most of the task. In addition, he or she can name parts, tools and simple facts about the task. The following is a minimum list of devices associated with this task.

Safety Wire:

The combination of constant vibration and changing temperatures in an aircraft are the primary causes for loosening of connectors and fasteners. All aircraft connectors and critical equipment fasteners that are not self-locking are safety wired with lock wire. Individuals should be able to explain the use of safety wire with reference to the following terms:

- Safety Device/Tool
  - Safety wire pliers that lock and unlock by squeezing the handles
  - Wire is cut using side cutters on the pliers
- Types and Sizes of Safety Wire
  - Safety wire, or lock wire, comes in many sizes ranging from 0.020 inch to 0.041 inch in diameter
  - The 0.032-inch safety wire is a general- purpose safety wire used mostly for securing equipment fasteners
  - Do not use the heavier wire on connectors because the wire will break out the holes drilled in the connector collars
  - Use the 0.020-inch safety wire on electrical connectors and small screws
- Acceptable Safety Wire Practices
  - Use correct size and size of safety wire
  - Ensure that there are a appropriate number of twist per inch of wire
  - Ensure that the proper tension is placed on the wire
  - Ensure that the safety is in a proper direction
  - Ensure that there is an appropriate pigtail
  - Keep track of clippings and dispose of them properly because they pose a serious FOD hazard
  - Do not let safety wire come into contact with adjacent parts or assemblies

Shear Wire:

Individuals should be able to explain the use of shear wire with reference to the following terms:

- Shear Wire
  - Type of 0.20 inch diameter safety wire made of copper or brass
  - Shear wire is used for safetying emergency equipment and is designed to break when a force is applied
- Emergency Equipment using Shear Wire
  - Switch handles
  - Guards covering handles used as exits
  - Fire extinguishers

## 30. Aircraft Wiring

### NCATT Level A

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to the recognition, selection and use of aircraft wiring.

Coaxial Aircraft Wire:

Individuals should be able to explain coaxial aircraft wire and its uses with reference to the following terms:

- Coaxial Aircraft Wire
  - One center wire surrounded by a metallic braided shield
- Use of Coaxial Aircraft Wire
  - Used for data transmission and RF signal distribution
  - Coaxial wire is the standard transmission medium for the Ethernet, a computer networking technology for Local Area Networks (LANs)

**Note**: For Information on Sleeving Types, AWG standards, Conductors and Plating, Criteria for the Selection of Electrical Wire, Wires Commonly used in Aircraft, and Cables Commonly used in Aircraft—See Aircraft Wiring/ Multiconductor.

Multiconductor:

Individuals should be able to explain multiconductor aircraft wire and its uses with reference to the following terms:

- American Wire Gage (AWG)
  - Wire sizing standard
  - As the gage numbers become larger, the wire diameters get smaller
  - Wire sizing factors include the following
    - Allowable power loss
    - Permissible voltage drop
    - Current carrying ability
- Cables Commonly used in Aircraft
  - Includes the following standards (military)
    - MIL-W-5086
    - MIL-W-7072
    - MIL-W-7139
    - MIL-W-8777
    - MIL-W-16878
    - MIL-W-22759
    - MIL-W-25038

    - MIL-W-273000
- Common Insulating Materials
    - Includes plastic, rubber, glass, ceramics, air (vacuum), or oil
- Conductors
    - Includes conductors made of copper and aluminum
    - Silver is very expensive, but it is sometimes used for conductors
    - Copper conductors have higher conductivity than aluminum.
    - Copper conductors are more ductile, have relatively high tensile strength, and are more easily soldered than aluminum
    - Copper conductors are more expensive and heavier than aluminum conductors
    - Aluminum conductors have 60% of the conductivity of copper
    - Aluminum conductors weigh less than copper
- Conductor Plating to Prevent Corrosion (Oxidation)
    - Includes tin, silver, and nickel
- Criteria for the Selection of Electrical Wire
    - Abrasion resistance
    - Arc resistance (non-carbon tracking)
    - Corrosion resistance
    - Cut-through strength
    - Flame resistance
    - Fluid resistance
    - Heat distortion temperature resistance
    - Notch propagation resistance
    - Smoke emissions resistance
- Multiconductor Aircraft Wire used for aircraft electrical power distribution systems (Two or more insulated wires in the same jacket) provides:
    - Dielectric strength
    - Impact strength
    - Mechanical strength
- Sleeving Types
    - Vinyl Sleeving
    - Nylon Sleeving
    - Silicon Rubber
    - Silicon Fiberglass

<u>Single Conductor Aircraft Wire:</u>

Individuals should be able to explain single conductor aircraft wire and its uses with reference to the following terms:

- Single Conductor Aircraft Wire
    - One insulated wire in a jacket

- Single conductor aircraft wire is used in aircraft electrical systems
- Most aircraft electrical systems are of the single conductor wire-type
- Single conductor wire means the structure of the aircraft provides an electrical path for the current to return to the source

Twisted Pair Aircraft Wire:

Individuals should be able to explain twisted pair aircraft wire and its uses with reference to the following terms:

- Twisted Pair Aircraft Wire
  - Two or more separately insulated wires twisted together
- Uses of Twisted Pair Aircraft Wire
  - Used in aircraft onboard communications and circuits
  - For example, twisted pair aircraft wire is used in lighting circuits for the standby magnetic compass
  - Twisted pair wire is also a transmission medium for the Ethernet, a computer networking technology for Local Area Networks (LANs)

### 31. Perform Wire Maintenance
**NCATT Level 3c**

Outcome: A successful education or training outcome for this task/subject will produce an individual who is competent in the performance task of "Performance of Wire Maintenance". The individual will be able to do all parts of the task and will need only a spot check of completed work. In addition, he or she will know the operating principles used with this standard, and can identify why and when the task must be done and why each step is needed. The following is a minimum list of performance items associated with this task.

**Note**: Ensure test equipment and tools required are calibrated to perform continuity checks.

Continuity Checks/Tests:

Individuals should be able to explain and demonstrate how to measure the continuity of a conductor and a switch using an ohmmeter on a multimeter with reference to the following terms:

- Continuity Check/Tests
  - Facilitates the tracing of circuit paths to ensure current is flowing from one end of the circuit to the other
- Continuity Checks/Tests
  - Identifies good fuses from bad fuses
  - Identifies open or shorted conductors
  - Verifies operation of switches

    - Identifies good or faulty lamps
- Multimeter
    - Multi-function meter are used to test current values, voltage values, or ohmic values (resistance)
    - A multimeter can be configured as an ammeter, voltmeter, or ohmmeter
    - Multimeter displays are provided in both analog and digital format
- Ammeter
    - Electrical testing instrument used to measure DC flowing in an electrical circuit
    - An ammeter shows the value in amps
    - The ammeter and voltmeter measure current; they differ in the way each is connected in a circuit.
- Voltmeter
    - Electrical testing instrument used to measure voltage by connecting resistance in a series with the meter movement
    - A voltmeter shows the value in volts
    - A voltmeter provides an effective way to test the continuity of lighting system wire in an aircraft
- Ohmmeter
    - Electrical testing instrument used to measure resistance in a circuit or component
    - An ohmmeter shows the value in ohms
    - Ohmmeters provide an effective and quick way to test the condition of a switch
    - Ohmmeters measure current, but it provides its own source of power
    - Ohmmeters also contain other auxiliary circuits

## 32. Use Test Equipment / Special Tools
### NCATT Level 2b

Outcome: A successful education or training outcome for this task/subject will produce an individual who is partially proficient in the performance task of "Use of Test Equipment / Special Tools". The individual will be able to do most parts of the task and will need help only on the hardest parts. In addition, he or she will know the task procedures, and can determine the step-by-step procedures for doing the task. The following is a minimum list of terms and task associated with this subject.

**Note**: Ensure test equipment and tools required are calibrated.

Analog/Digital Multimeters:

Multimeters are versatile measuring instruments. Individuals should be able to explain and demonstrate how to properly connect and measure voltage, current, and resistance in an electrical circuit using a multimeter with reference to the following terms:

- Multimeter

    - See Perform Wire Maintenance Continuity Checks and Basic Circuit Calculations DC/AC Measurements
- Analog Multimeter
    - Measured as ohms/volts (Typically 20K ohms or greater)
    - Analog multimeters require 50 micoamps of current to move the point full scale
- Digital Multimeter
    - Measured as ohms/volts
    - Digital multimeters allow for the largest allowable error that can occur under a specific condition
    - Allowable error is an indication of how close a meter's displayed value is to the actual value of the signal being measured

Oscilloscopes:

Oscilloscopes are basic instruments for analyzing digital data signals. Individuals should be able to explain and demonstrate how to properly connect and use an oscilloscope to display voltage levels and frequency with reference to the following terms:

- Oscilloscopes
    - Electronic test instrument that displays the waveforms of electrical signals
    - Oscilloscopes measure voltages (AC peak-to-peak values) and time to determine frequencies. An oscilloscope displays phase relationships (comparisons of waveforms in time) to identify equipment malfunctions.
- RF and Microwave Measurement Scopes
    - Analog Oscilloscopes amplify the signal measured and display the signal at a specific sweep rate
    - Digital Oscilloscopes use high-speed sampling to convert the signal measured into a series of "digital words" that are stored in the memory of the oscilloscope

## IV. Aircraft Fundamentals

### 33. Aircraft Structures
**NCATT Level A**

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to recognition of fundamentals of aircraft structures, aircraft terminology, and theory of flight. The following is a minimum list of terms associated with this subject.

Aviation Terminology:

Individuals should be able to explain basic aviation facts and terminology with reference to the following terms:

- Axis of Flight
  - Longitudinal Axis
    - Extends lengthwise through the aircraft fuselage from the nose to the tail
    - Motion along (about or around) this axis is called roll
  - Lateral Axis
    - Extends span wise through the aircraft from wing tip to wing tip
    - Motion along (about or around) this axis is called pitch
  - Vertical Axis
    - Extends through the center of the aircraft from the top to the bottom
    - Motion along (about or around) this axis is called yaw
- Forces of Flight
  - Center of Gravity (CG)
    - The point at which all of the weight of the aircraft is considered to be concentrated
  - Weight
    - Downward force exerted on an object caused by gravity
    - Gravity acts on everything in the aircraft, the crew, fuel, cargo, and aircraft itself
  - Lift
    - Upward force created by the effect of airflow as it passes over and under the wings
    - Lift counteracts the effects of weight
    - Lift and weight must remain equal for steady horizontal flight
  - Drag
    - Backward force caused by the disruption of airflow over the wings, fuselage, and any protruding objects
    - Drag opposes thrust, or forward motion of an aircraft
  - Thrust
    - Forward force produced by the powerplant.
    - Thrust and drag must remain equal for the aircraft to maintain a steady speed
- Fuselage
  - Central area of aircraft aft of the firewall and forward of the empennage
  - This area contains the cockpit or cabin
  - Depending on the size of the aircraft, there may be areas for passengers, cargo, and other aircraft components
  - Two basic types of fuselages are used in aircraft construction
    - Truss (sub-classified as Pratt truss and Warren truss)
    - Monocoque (sub-divided into three classes)
      - ❖ True Monocoque
      - ❖ Semimonocoque

        - ❖ Reinforced Shell
        - Semimonocoque / reinforced shell—Derives its strength from internal parts such as bulkheads, longerons, keel beams, and drag struts
        - Semimonocoque is often referred to as the most common type of fuselage construction
- Empennage Components (location tail or rear of the aircraft)
    - Empennage contains the vertical fin (stabilizer) upon which the rudder is located and attached
    - Empennage contains the horizontal stabilizer upon which the elevator is located and attached
- Streamlining and Drag Reduction for Airframes and Structures
    - Fairings
        - Curved piece of metal that provides aerodynamic smoothness of airflow over angled shapes of wings and fuselage appendages such as wheels, tail cones, and landing gear
        - Some fairings are removable, and others are attached to the structure of the aircraft
    - Drag Reduction
        - Drag can be reduced by reducing the number of exposed parts or streamlining their shape
        - Skin friction can be reduced by eliminating rivet heads (flush rivets) and irregularities on the fuselage, as well as using glossy flat finishes to reduce roughness
- Wings / Airfoil
    - Generate lift for flight
    - Spars carry the flight and landing loads
    - Wing structural types
        - Cantilever type
            - ❖ The most common and strongest type of wing design
            - ❖ Attached directly to the fuselage without any external, load-bearing structures (e.g. lift struts)
            - ❖ A single main spar, runs through the wing with the entire strength of the wing being provided by the main spar, and the wings internal structural elements
        - Semi-cantilever
            - ❖ Supported by wires or struts extending between each wing and the aircraft fuselage for external bracing

<u>Identify Flight Controls:</u>

Individuals should be able to explain basic facts about the theory of flight and flight controls with reference to the following terms:

- Ailerons(Primary Flight Control)
    - Controls roll about the longitudinal axis
    - Located on the outboard trailing edge of each wing
    - Turning the control wheel left or right, or movement of the stick left or right controls the ailerons
- Elevator (Primary Flight Control)
    - Controls pitch about the lateral axis
    - The elevator is attached and hinged (moveable) to the trailing edge of the fixed horizontal stabilizer
    - Moving the control wheel or stick rearward will cause the trailing edge of the elevator to move up, and the elevator is considered to be moving upward, with a corresponding aircraft nose pitch up about the longitudinal axis
    - Moving the control wheel or stick forward will cause the trailing edge of the elevator to move down, and the elevator is considered to be moving downward, with a corresponding aircraft nose pitch down about the longitudinal axis
    - A stabilator combines the horizontal stabilizer and elevator into one unit
- Rudder (Primary Flight Control)
    - Controls yaw about the vertical axis
    - A rudder is attached and hinged (moveable) to the vertically fin (vertical stabilizer)
    - A rudder is operated by foot-petals in the cockpit or cabin
    - In flight stepping or pushing on the right rudder pedal will cause the trailing edge of the rudder to move to the right (right rudder) and the aircraft will yaw (aircraft nose will move) about the vertical axis to the right
    - In flight stepping or pushing on the left rudder pedal will cause the trailing edge of the rudder to move to the left (left rudder) and the aircraft will yaw (aircraft nose will move) about the vertical axis to the left
    - During taxi moving the rudder pedals left or right will cause a change in the taxi direction corresponding to the rudder pedal being pushed
- Flaps (Secondary Flight Control)
    - Provide increased lift, drag, and wing area for takeoff and landing
    - Flaps are located inboard of the ailerons on the trailing edge of the wings
- Trim Tabs (Secondary Flight Control)
    - Located on the trailing edge of primary flight controls
    - Tabs are adjusted to aerodynamically move or maintain primary flight control positions thereby reducing the effort and workload on the pilot

<u>Theory of Flight:</u>

- Bernoulli's Principal
    - The principal states: "As the velocity of a fluid (air) increases, its internal pressure decreases"

    - On a typical aircraft cambered wing air flowing over the curved (cambered) top surface of a wing reaches the trailing edge of a wing at the same time as air flowing along the flat bottom of a wing
    - Due to the curved (cambered) top surface of the wing, air flowing over the top of the wing has to travel farther, therefore faster than the air flowing under the wing to reach the wing's trailing edge at the same time (sometimes it actually speeds up to the point that it gets there first)
    - The main source of lift on an aircraft is this difference in air pressure between the upper and lower sections of the wing that is explained by Bernoulli's Principal
- Newton's Laws of Motion
    - Newton's First Law of Motion referred to as the law of inertia
    - A body at rest tends to remain at rest, and a body in motion tends to stay in motion unless acted upon by an outside force
    - Newton's Second Law of Motion referred to as the law of force
    - The acceleration produced in a mass by the addition of a given force is directly proportional to the force and inversely proportional to the mass
    - Newton's Third Law of Motion referred to as the law of action and reaction
    - For every action, there is an equal and opposite reaction
- Airfoil
    - Any surface on an aircraft that converts movement of air to an aerodynamic force when they interact

## 34. Aircraft Handling and Safety

### NCATT Level A

Outcome: A successful education or training outcome for this task/subject will produce an individual who can identify basic facts and terminology related to aircraft ground handling and safety. The following is a minimum list of terms and task associated with this subject.

Basic Aviation/Aircraft Fundamentals and Safety:

Individuals should be able to explain basic facts about aviation and aircraft fundamentals of safety with reference to the following terms:

**Note**: If specific manufacturer instructions for towing an aircraft are required, consult the manufacturer's towing and maintenance instructions in all instances.

- Ground Movement of Aircraft
    - Ground-handling personnel must be familiar with procedures for handling all aircrafts on the ground, as well as local operating standards governing aircraft ground-handling
- Ground-handling Team (TOW Team Large Aircraft)
    - One person in charge of the team

  - One qualified person in the cockpit to operate the brakes in case the tow bar fails or becomes unattached to the towing vehicle or another emergency occurs. This person is not in the cockpit to steer the aircraft.
  - One towing vehicle driver responsible for operating the vehicle in a safe manner. The driver should also be able to follow emergency stop directions given by any team member
  - Two wing-walkers to ensure adequate clearance of the wings from obstructions during aircraft movement
  - One tail-walker to assist with directing sharp turns and backing the aircraft into position, if necessary
  - One person in the cockpit to maintain the hydraulic system pressure, when necessary
- Towing of Aircraft
  - Use the proper tow bar. Some bars are designed and built by the manufacturer to be used with their product
  - Attach tow bar to the rear or front of the aircraft following the appropriate procedure
  - Aircraft equipped with tricycle landing gear are generally towed forward
  - Aircraft equipped with tail wheels are also generally towed forward by attaching the tow bar to the tow rings on the main gear
  - Make sure the locking scissors are set to full swivel if the aircraft has a steerable nosewheel. The locking scissors device must be reset after the tow bar is removed
  - Charge the braking system before towing
  - Ensure all entrance doors on the aircraft are closed, ladders are retracted, and gear locks are installed
  - Check all tires and landing gear struts for proper inflation
  - Contact the airport control tower on the appropriate frequency prior to movement of an aircraft across runways or taxiways. Wait until the tower personnel give permission to proceed
  - Keep the towing vehicle at a reasonable speed so the walking team can keep up with the aircraft. Do not stop and start quickly
  - Keep in radio contact with the person in the aircraft handling the braking. Aircraft brakes must never be applied unless there is an emergency command from one of the tow team members on the ground
  - Park aircraft in assigned area. If the aircraft is to be parked in a hanger, statically ground the aircraft immediately after parking the aircraft
  - Place wheel chocks fore and aft of the main landing gear of the aircraft
  - Set internal or external control locks (gust locks or blocks) to protect the aircraft while parked
- Remove Before Flight (RBF) Streamer
  - Components that jut-out from the aircraft such as intake/exhaust covers, plugs,

landing gear pins, locks, or pitot tubes must have a RBF streamer attached to it
    - The streamers, attached by safetying pins, are usually red and have "Remove Before Flight" in large white printed letters printed on the front
    - This streamer warns personnel of any dangers around the aircraft
    - Failure to remove the streamers can cause aircraft systems to become inoperative before and during flight
- Safety Precautions
    - Once the tow bar is attached, persons in the aircraft must not attempt to steer the aircraft
    - No one is permitted to walk or ride under the aircraft; ride between the towing vehicle and the nose of the aircraft; or ride on the outside of the towing vehicle or the aircraft while the aircraft is moving
    - No one is permitted to board or leave the aircraft or towing vehicle while the vehicles are moving
    - Aircraft engines are not operated during towing. If the engines must be in operation, special precautions must be taken
    - Throughout towing operations, chocks must be immediately available
- Taxing of Aircraft
    - Only rated Pilots and qualified A & P Technicians are allowed to start, run up, or taxi aircraft. These operations must be in accordance with applicable local regulations
- Storage of Aircraft
    - Storage facilities provide a protective environment for equipment, parts inventories, and supportive materials, such as de/anti-icing materials and sand. Follow the manufacturer's instructions for storage and removal from storage of an aircraft
- Aircraft Pre- and Post-flight Inspection
    - *Preflight*—Suggested preflight functions and checks that avionics/ electronics technician should perform prior to an aircraft's first flight following repair, service or installation of avionics/electronics equipment, and subsequent to completion of all required documentation and record keeping requirements.
        - Ensure the aircraft's on-board battery provides power to each avionics/electronics unit
        - Ensure the aircraft's external power supply provides power to each avionics/electronics unit independent of the aircraft's battery
        - Ensure the avionics/electronic circuit protection devices function properly and are set in the correct operational position
        - Visually inspect for security of avionics/electronics components (look under and behind the instrument panel)
        - Walk around the aircraft and look for any discrepancies (damage to the aircraft) that may have existed prior to (should have been noted at the time

the aircraft entered the avionics shop) or subsequent to the performance of avionics/electronics work
        - Check for missing panels and close out fairings
        - Visually inspect all antennas for the following:
            - Security
            - Missing fasteners
            - Skin cracks
            - Deteriorated and damaged seals
            - Inadvertently painted antennas
    - Postflight—Suggested postflight functions and checks that an avionics/electronics technician should perform after an aircraft's first flight following repair, service, or installation of avionics/electronics equipment
        - Repeat visual inspections performed during preflight inspections both internally and externally to ensure that all components are secure
        - Perform postflight documentation requirements

Safety: Operational Risk Management/Fall Protection:

The OSHA "General Duty Clause" requires employers to furnish to each of their employees a place of employment which is free from recognized hazards that are likely to cause death or serious physical harm to their employees. The General Duty Clause requires employers to comply with occupational safety and health standards promulgated under this act.

Identifying good safety practices and deciding how best to protect workers is the first step in reducing or eliminating safety hazards. The use of safe work practices and training enables employees to do their job properly. Individuals should be able to explain causes of accidents and proper techniques to use when lifting or moving objects and preventing falls.

Causes of Accidents in the workplace:

- Human Factors
    - Most errors are in thinking and/or attitude rather than lack of knowledge
    - The number one causal factor in the technical/maintenance area is 80% human error
    - FAA's Dirty Dozen in the Workplace
        - Lack of communication
        - Lack of teamwork
        - Norms
        - Pressure
        - Complacency
        - Lack of knowledge
        - Lack of awareness
        - Lack of resources

        - Distraction
        - Lack of assertiveness
        - Fatigue
        - Stress
- Proper Techniques for Avoiding Falls
    - Any time a worker is at a height of four feet or more, the worker is at risk
    - Read your company's written fall prevention plan
    - Attend and participate in fall prevention training
    - Get specialized training before working on scaffolds, lifts, or ladders
    - Use the appropriate fall protection equipment, if required for the job
    - Inspect fall protection equipment and devices before each use
    - Make sure that floor holes, open shafts, riser penetrations, and skylights are protected by sturdy guardrails or covers
    - Keep your feet firmly on the platform of a boom lift and tie-off at all times
    - Choose the correct ladder for the task
    - Make sure a ladder is in good condition prior to use
    - Check for stable footing and the proper angle when using a ladder
    - Never stand on the top rung of a ladder
    - Contact your supervisor if you see fall hazards or have any questions
    - Practice good housekeeping
    - Keep cords, welding leads, and air hoses out of walkways
- Proper Techniques for Lifting or Moving Objects
    - Read your company's written plan for lifting a load
    - Attend and participate in back injury prevention training
    - Before lifting a load, check for potential hazards on the load such as slippery areas or sharp corners
    - When getting ready to lift a load, keep your feet comfortably apart, about shoulder width. Secure your footing
    - Get close to the load. Do not reach while lifting
    - Turn your feet; never twist your back when you lift a load
    - Bend at your knees, not your waist to lift the load. Use your legs to help distribute the weight of a load when lifting
    - Keep your back straight and get a firm grip on the load
    - Keep the load close to your body
    - Use the same procedures to place the load after lifting