



# Electrical Power Testing

## Level III Certification Content Outline

### Standard Model/Computer-Based Testing

*The candidate for NICET certification as a Level III Electrical Power Testing technician should have the knowledge and experience to:*

Manage switching procedures;  
conduct tests of complex (multi-function) equipment;  
analyze test and equipment data; plan a job and lead a team.

*Note: For each exam, the skills and knowledge listed under each task are suggestive of those involved in that task, but are not intended to constitute an exhaustive listing.*

### 3.1 Field Testing

*(Approximately 65 - 70% of the exam)*

#### 3.1a Transformers and Regulators

##### 3.1a.1 Select appropriate tests and test equipment.

**Knowledge:**

Purposes of and equipment required for various tests  
Factors that constrain the application of various tests  
Structures, electrical pathways, and functions specific to particular types of transformers and regulators

**Skills:**

Recognize the tests required for specific applications.  
Verify the range and capacity of test equipment.  
Verify that the test equipment has been calibrated.  
Recognize and interpret customer specifications, manufacturer specifications, and industry standards.

##### 3.1a.2 Perform complex electrical tests.

**Knowledge:**

NETA ATS/MTS  
IEEE C57, Sections 12.90 and 12.91  
NFPA 70B, Chapter 21  
Test procedures and constraints  
Structures, electrical pathways, and functions specific to particular types of transformers and regulators

**Skills:**

Measure core insulation resistance.  
Measure the insulation power-factor/dissipation-factor on all windings.  
Measure the power-factor/dissipation-factor on bushings.  
Measure excitation current in accordance with the test equipment manufacturer's published data.  
Measure turns ratio at all de-energized tap and LTC positions.  
Perform an overpotential test.

##### 3.1a.3 Evaluate standard liquid tests.

**Knowledge:**

Implications of the presence of various dissolved gases  
ASTM D877  
Scopes of ASTM Standards D924, D971, D974, D1298, D1500, D1524, D1533, D1816, D2285, D4059  
IEEE C57.104, C57.106

**Skills:**

Perform and evaluate dielectric breakdown voltage.  
Evaluate visual condition.  
Evaluate acid neutralization number.  
Evaluate specific gravity.  
Evaluate interfacial tension.  
Evaluate color.  
Evaluate water content.  
Evaluate PCB content.  
Evaluate dissolved gas-in-oil.  
Evaluate dissipation-factor/power-factor.

#### 3.1b Breakers and Contactors

##### 3.1b.1 Select appropriate tests and test equipment.

**Knowledge:**

NETA MTS/ATS  
Purposes of and equipment required for various tests  
Factors that constrain the application of various tests  
Structures, electrical pathways, and functions specific to particular types of breakers and contactors

**Skills:**

Recognize the tests required for specific applications.  
Verify the range and capacity of test equipment.  
Verify that test equipment has been calibrated.  
Recognize and interpret customer and manufacturer specifications and industry standards.



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## **3.1b.2 Perform visual inspection and functional tests, including operational tests, and time/travel analysis.**

### **Knowledge:**

NFPA 70B, Chapters 11, 15, 17  
NETA ATS/MTS  
Mechanical functioning and basic functional requirements of breakers and contactors  
Test procedures

### **Skills:**

Operate breakers and contactors to verify smooth operation.  
Inspect and evaluate mounting, anchorage, and alignment.  
Remove a sample of SF6 gas.  
Verify cell fit and racking mechanism as applicable.  
Use travel analyzer to perform time/travel analysis.

## **3.1b.3 Perform electrical tests.**

### **Knowledge:**

NFPA 70B, Chapter 21  
NETA ATS/MTS  
Test procedures and constraints  
Structures, electrical pathways, and functions specific to particular types of breakers and contactors

### **Skills:**

Measure and evaluate insulation resistance.  
Measure and evaluate contact resistance.  
Perform and evaluate power-factor/dissipation-factor test.  
Perform and evaluate electrical operation as applicable.  
Perform and evaluate trip characteristic verification as applicable.  
Determine proper connection points and equipment circuits.

## **3.1c Cables and Busways**

### **3.1c.1 Select appropriate tests and test equipment.**

#### **Knowledge:**

NETA ATS/MTS  
Purposes of and equipment required for various tests  
Factors that constrain the application of various tests  
Various types of cable construction  
Various types of busway construction

#### **Skills:**

Recognize the tests required for specific applications.  
Verify the range and capacity of test equipment.  
Verify that test equipment has been calibrated.  
Recognize and interpret customer specifications.

### **3.1c.2 Perform visual inspection of cabling and busways.**

#### **Knowledge:**

NFPA 70B, Chapter 11, 19, 20  
Requirements for and methods of cable and busway support and cable shielding  
Signs and causes of cable stress  
Correct termination for neutral and ground conductors and correct placement of shields for protective device operation

#### **Skills:**

Read and interpret schematics.  
Determine the correct compression and indentation of cable terminals.  
Visually check cable ratings for conformance with schematics.  
Inspect for proper stress reduction devices.  
Inspect for proper shield grounding.  
Verify correct bending radius.

### **3.1c.3 Perform and evaluate electrical tests.**

#### **Knowledge:**

IEEE 400, 400.1, 400.2, 400.3  
NETA MTS/ATS  
NFPA 70B, Chapter 11, 19, 20  
Test procedures and constraints

#### **Skills:**

Evaluate insulation resistance test.  
Evaluate shield continuity test.  
Evaluate DC overpotential withstand test.  
Perform and evaluate a time domain reflectometer test.  
Perform and evaluate AC and very low frequency (VLF) overpotential withstand tests.  
Perform and evaluate diagnostic tests, including VLF tan delta, power factor/dissipation factor, and online and offline partial discharge.

### **3.1d Switchgear, Switchboards, Motor Control Centers, Switching Devices, & Fuses**

#### **3.1d.1 Select appropriate tests and test equipment.**

##### **Knowledge:**

NETA MTS, NETA ATS  
Purposes of and equipment required for various tests  
Factors that constrain the application of various tests  
Structures, electrical pathways, and functions specific to particular types of devices

##### **Skills:**

Recognize the tests required for specific applications.  
Verify the range and capacity of test equipment.  
Recognize improper or outdated calibration.  
Recognize and interpret customer specifications.



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## **3.1.d.2 Perform visual and mechanical inspection.**

### **Knowledge:**

NFPA 70, Articles 240, 250, 312, 404, 408, and 490  
NFPA 70B, Chapters 11, 15, 16, 18  
NETA MTS, NETA ATS  
Mechanical functioning and construction requirements of switchgear, switchboards, motor control centers, switching devices, and fuses

### **Skills:**

Inspect the cell/breaker interface and alignment.  
Test and verify mechanical interlocks and rejection hardware.  
Verify nameplate data and compare with project specifications.  
Verify equipment compatibility.  
Inspect all connections for tightness, integrity, continuity, conformance with electrical plans.  
Perform the mechanical operation sequence.  
Inspect instrument transformers.

## **3.1.d.3 Perform and evaluate electrical tests.**

### **Knowledge:**

NFPA 70B, Chapters 11, 15, 16, 18  
NETA MTS, NETA ATS  
Test procedures and constraints  
Structures, electrical pathways, and functions specific to particular types of devices, including overloads, current transformers, RTDs, potential transformers, ground fault protection, and zone interlocking.

### **Skills:**

Test all control, power, current, and potential transformers.  
Test and verify electrical interlocks.  
Perform and evaluate ground resistance test.  
Evaluate insulation resistance test results: phase-to-phase and phase-to-ground.  
Perform and evaluate insulation resistance test on control circuits.  
Perform functional testing of zone interlocking and control circuits.  
Measure and evaluate resistance through all bolted connections with a low resistance ohmmeter.  
Evaluate overpotential test results.  
Perform point-to-point wiring checks of all control circuits in new installation.

## **3.1.d.4 Check fuse types, ratings, and applications.**

### **Knowledge:**

Fuse types, ratings, and their representation

### **Skills:**

Compare nameplate fuse data with design drawings, short circuit study, and/or specifications.  
Compare control fuse types and ratings to schematics.  
Perform and evaluate a fuse resistance test.  
Inspect mounting and clearances.

## **3.1e Protective Relays and Metering**

### **3.1.e.1 Select appropriate tests and test equipment.**

#### **Knowledge:**

NETA MTS, NETA ATS  
Purposes of and equipment required for various tests  
Factors that constrain the application of various tests  
Structures, electrical pathways, and functions specific to particular types of relays and meters

#### **Skills:**

Recognize the tests and test equipment required for specific applications.  
Verify the range and capacity of test equipment  
Verify calibration of test equipment.  
Recognize and interpret customer specifications.

### **3.1.e.2 Perform electrical testing and visual and mechanical inspection of multifunction relays.**

#### **Knowledge:**

NFPA 70B, Chapter 11, 16  
NETA MTS, NETA ATS  
Structures, electrical pathways, and functions of multifunction relays

#### **Skills:**

Check connections and physical condition.  
Recognize functions of relays.  
Test and evaluate each relay function using an appropriate single or 3-phase relay test set.  
Determine appropriate test sequence & characteristics.  
Apply voltage and/or current in the proper frequency and phase relationship to test and prove each relay function.  
Program digital relays for CT/PT ratio, significant digits, & any specified functions required for the application.  
Follow instruction manuals for the device being tested as well as for the test equipment being used.

### **3.1.e.3 Perform electrical testing and visual and mechanical inspection of differential relays.**

#### **Knowledge:**

NFPA 70B, Chapter 11, 16  
NETA MTS, NETA ATS  
Structures, electrical pathways, and functions of differential relays

#### **Skills:**

Check connections and physical condition.  
Recognize functions of relay.  
Test and evaluate each relay function using a single and 3-phase relay test set.  
Determine appropriate test sequence & characteristics.  
Apply voltage and/or current in the proper phase relationship to test and prove each relay function.  
Program digital relays for CT/PT ratio, significant digits, & any specified functions required for the application.  
Follow instruction manuals for the device being tested as well as for the test equipment being used.



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## **3.1e.4 Perform electrical testing and visual and mechanical inspection of power relays.**

### **Knowledge:**

NFPA 70B, Chapter 11, 16

NETA MTS, NETA ATS

Structures, electrical pathways, and functions of power relays

### **Skills:**

Check connections and physical condition.

Recognize the functions of a relay.

Test and evaluate each relay function using a single and 3-phase relay test set.

Determine appropriate test sequence & characteristics.

Apply voltage and/or current in the proper phase relationship to test and prove each relay function.

Program digital relays for CT/PT ratio, significant digits, & any specified functions required for the application.

Follow instruction manuals for the device being tested as well as for the test equipment being used.

## **3.1e.5 Perform electrical testing and visual and mechanical inspection of watt meters, VAR meters, and multifunction power meters.**

### **Knowledge:**

NFPA 70B, Chapter 15.9.7

NETA MTS, NETA ATS

Structures, electrical pathways, functions, and scales of watt meters, VAR meters, and multifunction power meters

### **Skills:**

Check connections and physical condition.

Test and evaluate meter accuracy using a single and 3-phase relay test set.

Verify the meter's indication at cardinal points of the meter scale.

Program digital meters for CT/PT ratio, significant digits, and any specified functions required for the application.

## **3.1e.6 Perform electrical testing and visual and mechanical inspection of watt-hour meters.**

### **Knowledge:**

NFPA 70B, Chapter 15.9.7

NETA MTS, NETA ATS

Structures, electrical pathways, functions, and scales of watt-hour meters

### **Skills:**

Check connections and physical condition.

Test, evaluate, and adjust meter accuracy using a single or 3-phase relay test set.

Verify the meter's indication at a discrete time interval.

Program digital meters for CT/PT ratio, significant digits, and any other functions required for the application.

## **3.1e.7 Perform electrical testing and visual and mechanical inspection of transducers.**

### **Knowledge:**

NFPA 70B, Chapter 15.9.7

NETA MTS, NETA ATS

Structures, electrical pathways, and functions of transducers

### **Skills:**

Check connections and physical condition.

Test, evaluate, and adjust transducer accuracy using a single or 3-phase relay test set.

Follow instruction manuals for the device being tested as well as for the test equipment being used.

## **3.1e.8 Perform functional tests on motor overload relays, relay trip devices, over-current relays, voltage relays, directional overcurrent relay, phase balanced/differential devices, solid state/microprocessor-based low voltage breaker protective devices, differential relays, power relays, and transducers.**

### **Knowledge:**

NETA MTS, NETA ATS

Mechanical functioning and basic functional requirements of relays and transducers

### **Skills:**

Read and interpret schematics.

Determine the function paths of relays under test.

Operate relays and verify trip sequence.

Develop procedures to test protection control circuit.

Measure current and voltage phase relationship to verify CT and PT polarity for conformance with the design application.

## **3.1f Rotating Machinery**

### **3.1f.1 Select appropriate tests and test equipment.**

#### **Knowledge:**

NETA ATS/MTS

Purposes of and equipment required for various tests  
Factors that constrain the application of various tests  
Structures, electrical pathways, and functions specific to particular types of rotating machinery

#### **Skills:**

Recognize the tests required for specific applications.

Verify the range and capacity of test equipment.

Verify that test equipment has been calibrated.

Recognize and interpret customer and industry specifications.



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## **3.1f.2 Visually and mechanically inspect motors and generators.**

### **Knowledge:**

NETA ATS/MTS

Functions and basic functional requirements of brushes and slip rings

Functions and basic functional requirements of bearings and lubrication systems

Functions and basic functional requirements of coolers and cooling systems

### **Skills:**

Read and interpret manufacturers' specifications.

Inspect and evaluate mounting.

Inspect and evaluate brushes.

Inspect and evaluate slip rings and commutators.

Inspect and evaluate bearing insulation.

Inspect and evaluate alignment and wear of brushes, slip rings, and commutators.

Inspect and evaluate machine space heaters.

Inspect and evaluate machine grounding and bonding.

Inspect and evaluate cooling system.

Inspect and evaluate bearing lubrication system.

Verify conformance of RTDs with specifications.

## **3.1f.3 Perform electrical tests.**

### **Knowledge:**

NEMA MG-1

NETA ATS/MTS

IEEE 43, 95

Test procedures and constraints

Structures, electrical pathways, and functions specific to particular types of rotating machinery

### **Skills:**

Verify diode polarity on static exciters.

Evaluate the insulation resistance.

Evaluate the winding resistance.

Evaluate the resistance through bolted electrical connections.

Perform and evaluate a power-factor/dissipation-factor tip-up test.

Perform and evaluate an overpotential test.

Perform and evaluate a surge comparison test.

Measure and evaluate the resistance of a RTD.

Calculate the polarization index and dielectric absorption ratio.

## **3.1g Battery Systems**

### **3.1g.1 Select appropriate tests and test equipment.**

#### **Knowledge:**

NETA ATS/MTS

Purposes of and equipment required for various tests

Factors that constrain the application of various tests

Structures, electrical pathways, and functions specific to particular types of battery chargers

#### **Skills:**

Recognize the tests required for specific applications.

Verify the range and capacity of test equipment.

Recognize & interpret customer & industry specifications.

### **3.1g.2 Perform electrical tests.**

#### **Knowledge:**

NFPA 70B, Chapter 11

NETA MTS, NETA ATS

Test procedures and constraints

Structures, electrical pathways, and functions specific to particular types of battery chargers

#### **Skills:**

Review and evaluate basic schematics.

Perform and evaluate a load test on batteries.

Perform and evaluate functional testing of control circuits.

Operate all active devices.

Evaluate need for equalization.

Operate an impedance test set.

## **3.1h Surge Arresters, Capacitors, and Reactors**

### **3.1h.1 Select appropriate tests and test equipment.**

#### **Knowledge:**

NETA MTS, NETA ATS

Purposes of and equipment required for various tests

Factors that constrain the application of various tests

Structures, electrical pathways, and functions specific to particular types of surge arresters, capacitors, and reactors

#### **Skills:**

Recognize the tests required for specific applications.

Verify the range and capacity of test equipment.

Recognize and interpret customer and industry specifications.

### **3.1h.2 Perform and evaluate mechanical and electrical tests.**

#### **Knowledge:**

NFPA 70, Article 460

NFPA 70B, Chapter 11

NETA MTS, NETA ATS

Test procedures and constraints

Structures, electrical pathways, and functions specific to particular types of surge arresters, capacitors, and reactors

#### **Skills:**

Verify capacitor discharge.

Perform and evaluate a power-factor/dissipation-factor test.

Verify the correct rating and application in accordance with basic one-line diagrams.



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## 3.1i Grounding Systems

### 3.1i.1 Select appropriate tests and test equipment.

**Knowledge:**

NETA MTS, NETA ATS

Purposes of and equipment required for various tests  
Factors that constrain the application of various tests  
Structures, electrical pathways, and purposes specific to particular types of grounding systems

**Skills:**

Recognize the tests required for specific applications.  
Verify the range and capacity of test equipment.  
Verify that test equipment has been calibrated.  
Recognize and interpret customer specifications.

### 3.1i.2 Evaluate mechanical and electrical tests.

**Knowledge:**

NETA MTS, NETA ATS

NFPA 70, Article 250

NFPA 70B, Chapters 11 and 14

IEEE 81

IEEE 142, Section 4.4

Test procedures and constraints

Structures, electrical pathways, and purposes specific to particular types of grounding systems

**Skills:**

Inspect bonds, clamps, welds, and verify proper torque applied to bolted connections on bonded components.  
Evaluate data points and test results for fall-of-potential, 2-point, clamp-on, slope method, intersecting curves, earth resistivity, step potential, and touch potential tests for acceptability per specifications or standards.  
Perform calculations for final resistance.

## 3.1j Infrared Surveys

### 3.1j.1 Perform and evaluate thermographic inspections of electrical distribution systems.

**Knowledge:**

NFPA 70B, Chapter 11

NFPA 70E, Annexes C, D, and H

NETA ATS, NETA MTS

Sources of emissivity data for materials

**Skills:**

Operate infrared cameras to obtain thermal images.  
Interpret thermographic images based on knowledge of materials and emissivities.  
Identify, measure, and record thermal anomalies.

## 3.2 Safety

(Approximately 10 - 15% of the exam)

### 3.2a General Safety

#### 3.2a.1 Develop and review a safety plan for a work site.

**Knowledge:**

OSHA 29 CFR 1910 and 1926

NFPA 70E

**Skills:**

Read and interpret building and site plans.  
Assess a site for existing hazards and exit routes.  
Assess the safety implications of proposed testing procedures and contingencies.  
Identify and review existing site evacuation plans.  
Establish/verify communications procedures.  
Prepare a safety plan.  
Instruct test team on hazards and proposed evacuation procedures.

### 3.2b Lockout and Tagout

#### 3.2b.1 Identify all sources of energy and their hazards.

**Knowledge:**

Operational characteristics of equipment being switched

**Skills:**

Read and interpret electrical drawings (single-line, three-line, and schematic).  
Identify sources of mechanical energy.  
Identify sources of electrical energy.  
Identify sources of potential feedback.

#### 3.2b.2 Review personal and site-specific lockout and tagout procedures.

**Knowledge:**

OSHA 29 CFR, Parts 1910.147 and 1910.269

NFPA 70E, Article 120

Human and written sources of lockout and tagout information

**Skills:**

Verify that electrical drawings conform to actual site conditions.  
Determine site-specific procedures.  
Verify that lockout and tagout conform to site-specific procedures.



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## **3.2b.3 Evaluate existing switching procedures.**

### **Knowledge:**

Sources of switching information  
NFPA 70B, Chapter 7  
NFPA 70E, Article 120  
OSHA 29 CFR 1910.333

### **Skills:**

Read and interpret system switching procedures.  
Determine the adequacy of procedures for intended isolation.

## **3.2b.4 Confirm switching.**

### **Knowledge:**

Switching device identification and operation

### **Skills:**

Verify a switching device's position.  
Verify that a switching procedure is complete.  
Verify the lack of potential in isolated area.

## **3.2b.5 Develop switching procedures.**

### **Knowledge:**

Effects of opening or closing a circuit branch on other branches  
Effects of changing electrical circuit conditions on equipment in the circuit

### **Skills:**

Identify the switching devices to be operated.  
Define the sequence of operation.  
Write out switching procedures in accordance with electrical schematics.

## **3.3 Troubleshooting and Analysis**

*(Approximately 10 - 15% of the exam)*

### **3.3.1 Use electrical drawings and site plans to determine the location of electrical devices and interpret sequences of operations.**

#### **Knowledge:**

IEEE C37.2, Sections 3 and 4  
IEEE 315  
NFPA 70B Annex F, G  
Ladder logic and control system flow charts

#### **Skills:**

Recognize standard electrical power system one-line drawing symbols, such as those for transformers, circuit breakers, disconnects, switches, motors, current transformers, protective relays, etc., as defined by IEEE, NFPA, and common engineering practice.  
Recognize standard electrical schematic and wiring diagram control symbols, such as those for contacts, relay coils, resistors, lamps, switches, etc., as defined by IEEE, NFPA, and common engineering practice.

### **3.3.2 Analyze and interpret tests performed by Level II and III technicians to determine the validity of the results.**

#### **Knowledge:**

NETA ATS, NETA MTS  
NFPA 70B, Chapter 11  
Acceptable test methods, voltages, and currents for Level II and III electrical tests  
Effects of test voltages, currents, and variations on test results for all electrical tests performed by Level II and III technicians  
Effects of temperature, humidity, and external conditions on test results for all electrical tests performed by Level II and III technicians.  
Limitations of test equipment  
Ways in which computer processing may modify data

#### **Skills:**

Review test data for possible errors and anomalies in methods and calculations.  
Determine corrective actions.

### **3.3.3 Determine serviceability of and recognize deficiencies in equipment being tested.**

#### **Knowledge:**

How to determine the operating characteristics and requirements of electrical equipment being tested by Level II and III technicians  
NETA ATS, NETA MTS

#### **Skills:**

Review manufacturers' specifications, including time current characteristic curves.  
Review test results recorded by Level II and III technicians and compare to manufacturers' specifications and industry standards to determine suitability of equipment for initial energization.  
Review test results recorded by Level II and III technicians and compare to manufacturers' specifications and industry standards to determine suitability for continued service.  
Compare current test results to historical data to determine deterioration or failure trends.  
Identify & recommend additional tests that will further define potential problems or imminent failures.

### **3.3.4 Identify and assess failures.**

#### **Knowledge:**

Effects of component failure at a point in a circuit upon voltage, current, resistance, impedance, and capacitance, at other points within series or parallel circuits

#### **Skills:**

Identify all failed components by visual inspections and test results.  
Assess the damage caused by a failure.  
Analyze schematics and wiring diagrams.  
Troubleshoot control circuits with control power energized or de-energized.



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## 3.4 Documentation

*(Approximately 1 - 6% of the exam)*

### 3.4.1 Prepare and review technical reports.

**Knowledge:**

Technical terminology and standard report content  
NFPA 70B, Annex H  
NETA MTS, NETA ATS 5.4 (Test Report)

**Skills:**

Accurately communicate graphic and textual information.  
Organize and format material to allow ready access to information by readers.  
Accurately report procedures, conditions, expected and actual results, and evaluations.  
Review contents of reports for accuracy and clarity of presentation.

## 3.5 Management and Planning

*(Approximately 1 - 6% of the exam)*

### 3.5.1 Prepare job plans for switching and testing.

**Knowledge:**

How to determine plant switching and isolation procedures  
Test equipment needed for specific tests, and requirements for equipment operation  
NETA MTS, NETA ATS  
NFPA 70B, Chapter 11  
NFPA 70E, Annexes C, D, I, and M

**Skills:**

Read and interpret switching procedures.  
Determine the procedures required by the particular job.  
Review client objectives and plant drawings to determine factors that will impact manpower, time, space, power, and PPE requirements.

### 3.5.2 Supervise one team of technicians.

**Knowledge:**

How an unexpected occurrence in one part of a team's work process can affect other parts

**Skills:**

Direct plant switching and isolation procedures.  
Direct test equipment usage for specific jobs.  
Delegate tasks and authority based on personnel availability, skills, and reliability.  
Provide on-the-job training.  
Provide clear instructions.

### 3.5.3 Apply ethics to management of work processes and customer relations.

**Knowledge:**

NFPA 70B  
NICET Code of Ethics

**Skills:**

Ensure the correct recording and approval of time worked and tasks completed.  
Ensure that correct testing procedures are followed and reported.  
Interpret the NICET Code of Ethics as it applies to all business relationships.

**Note on Standards:** A number of technical standards are listed in this Content Outline because they stand as authoritative sources of some of the critical knowledge required to properly perform a particular task. Successful candidates are expected to have a working knowledge of the relevant parts of the referenced standards. In other words, the candidate is expected to have the same knowledge of a referenced standard when taking a NICET test as he/she should have available by recall and interpretive thought when performing the task. (In some cases, standards are listed because they are the ultimate source of knowledge that is more typically acquired through secondary sources.)