NACE Cathodic Protection Technician (CP 2) Written Exam

Exam Preparation Guide

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NACE INTERNATIONAL INSTITUTE

Table of Contents

Introduction

The Cathodic Protection Technician (CP 2) written exam is designed to assess whether a candidate has the requisite knowledge and skills that a minimally qualified Cathodic Protection Technician must possess. The exam consists of 99 multiple-choice questions covering intermediate and basic areas of Cathodic Protection skills and knowledge. A candidate should have intermediate level knowledge of corrosion theory, CP concepts, types of CP systems, and advanced field measurement techniques.

Test Name	NACE- Cathodic Protection Technician (CP 2) Written Exam
Test Code	NACE-CP2-001
Time	2 ½ hours*
Number of Questions	99
Format	Computer Based Testing (CBT)

NOTE: A pass/fail grade is provided at the end of the exam.

**Exam time includes 4 minutes for the non-disclosure agreement and 6 minutes for the system tutorial.*

Note: Completion of course does not entitle the candidate to the certification.

Target Audience

Candidates for Cathodic Protection Technician (CP 2) should ideally have several years of CP field experience and possess intermediate level knowledge of corrosion theory, CP concepts, the types of CP systems in common use, and be competent with basic rectifier diagnostics, intermediate level field measurement techniques and equipment. CP Technician candidates could also be practicing technicians or engineers with a more modest level of cathodic protection experience, but with more significant relevant technical education.

Typically, Cathodic Protection Technicians are responsible for testing and maintaining the effectiveness of operating CP systems and components and supervising or assisting with the installation of CP systems. This includes troubleshooting, identifying interference conditions, performing over-the-line surveys and evaluating the results obtained.

Requirements

Cathodic Protection Technician (CP2)

Requirements for Cathodic Protection Technician:

■ 1 Prerequisite ■ Work Experience ■ 2 Core Exams ■ Application

The following prerequisite is required:
Successful completion of Cathodic Protection Tester (CP1), or equivalent training
Work Experience Requirements
Choose one of the following work experience options:
3 years verifiable CP work experience 2 years verifiable CP work experience **and** 2 year post high school training from approved math / science technical / trade school 1 year verifiable CP work experience **and** 4 year physical science or engineering degree
Core Exam Requirements
The following exams are required: (2 core exams required)
Cathodic Protection Technician (CP 2) exam (practical / hands on) Cathodic Protection Technician (CP 2) closed book exam (multiple choice, with relevant references)- NACE-CP2-001
Application Requirement:
Approved Cathodic Protection Technician (CP2) application

Note: Completion of course does not entitle the candidate to the certification.

Note: Cathodic Protection Technician (CP 2) exam (practical/ hands on exam) is only given at the conclusion of the NACE Cathodic Protection Technician Course. Separate arrangements should be made to take this portion of the exam should the candidate choose not to attend the course.

Submit Application – Candidates must apply for this certification by submitting an on-line application which is subject to approval.

Certification renewal requirements – Recertification application* required every 3 years –

- Minimum 1.5 years of work experience during the 3-year period prior to renewal
- A completed recertification application
- A minimum of 24 Professional Development Hours

Upon successful completion of requirements, the candidate will be awarded a **a Cathodic Protection Technician (CP 2) Certification** **Approval required*

CP2 – Knowledge and Skill Areas Tested

*NOTE***:** *At the end of the CBT exam the candidate will receive a bar chart of strengths and weaknesses that correspond to these Domains.*

Domain 1- Basics - 38-42%

- Be familiar with basic chemistry related to corrosion and role of acids and alkaline conditions.
- Understand how corrosion cells are formed on metal objects that are underground or otherwise immersed in an electrolyte.
- Be familiar with the Galvanic Series of metals.
- Understand the composition of a basic galvanic corrosion cell and the electrochemical reactions occur at the anode and the cathode.
- Understand and identify the forms of corrosion.
- Understand the physical and chemical characteristics of metals and electrolytes that at affect corrosion rate and polarization.
- Understand the cause and effect of polarization in a galvanic cell.
- Understand the relationship between voltage, current and resistance as expressed by Ohm's Law.
- Understand basic AC and DC circuits, including series, parallel and series-parallel.
- Understand the application of Kirchhoff's electrical circuit laws.
- Understand the concept of cathodic protection and the two primary methods of applying it to metal objects underground or otherwise immersed in an electrolyte.
- Understand and use the Nernst Equation to calculate the potential of a metal in a specific environment.
- Understand and use Evan's Diagrams to demonstrate the effects that various factors have on corrosion and cathodic protection.
- Understand the characteristics and application methods of common pipeline coatings.
- Understand the concept of shielding and how it can affect metallic objects that are cathodically protected.
- Understand the use of Faraday's first law in relation to cathodic protection and corrosion of metals.
- Be familiar with NACE standards and prominent international standards related to Cathodic Protection of steel and other structures in buried and immersed conditions.
- Be familiar with CP criteria in NACE and prominent international standards and special conditions or precautions related to their use.
- Understand and demonstrate the application of the E Log-I CP technique.
- Understand environmental and physical conditions that affect the application of CP criteria.
- Understand and demonstrate the applications and effects of electrically close and remote anodes.
- Understand what amphoteric material are the effect that cathodic protection may have on them.
- Understand the safety considerations and methods for dealing with spark hazards and current in piping.
- Understand Lock-Out/Tag-Out procedures.
- Understand common hazards related to cathodic protection work activities.

Domain 2-Rectifiers - 14-16%

- Be capable of reading electrical schematics.
- Use a digital volt-ohm meter (Multimeter) to determine the voltage and current output of a rectifier and the condition of diodes.
- Understand how to install and commission new rectifiers.
- Understand the procedure for performing an efficiency test on a rectifier.
- Understand a transformer rectifier circuit and be able to follow the input AC voltage through the transformer to the rectification stack and the DC from the stack to the load.
- Understand the types of rectifying circuits.
- Understand the principles of magnetism and how it applies to transformers.
- Repair rectifiers that have received damage from surges or lightning.
- Know how to change the connections of a rectifier to receive 240 Volts or 120 Volts input AC.
- Know how to test a transformers primary and secondary out of the circuit with an ohm meter.
- Know how to test a transformer in the circuit with an AC voltmeter.
- Know how to calculate the secondary voltage for a transformer.
- Understand the differences in a selenium and

silicon diodes and the advantages and disadvantages of each when used in a CP rectifier.
- Understand the various type of circuit breakers that can be used in CP rectifiers and the advantages and disadvantages of each.
- Understand the circuits required in CP rectifiers for single and three phase AC inputs and be able to troubleshoot them.
- Understand the various types of circuit configurations that can provide rectification: Full wave, single wave, full wave bridge.
- Understand the effects of filtering configurations used in CP rectifiers and the advantages each can provide.
- Know how to modify a CP rectifier that is found to be interfering with EFM, SCADA or radio communication signals.
- Know how to install chokes when the pulsating DC is causing problems with EFM calibration.
- Understand the different types of rectifier operating modes: constant voltage, constant current, constant potential.
- Understand the causes of common abnormal CP circuit conditions and their resulting effects on rectifier DC output.

Domain 3- CP Current Source - 1-3%

- Understand the basic aspects of common impressed current CP power sources other than transformer/rectifiers.
- Understand the different types of impressed current and galvanic anodes and their applications in soil and water environments.
- Install both impressed current and galvanic anodes, document the installation and test to insure proper operation.

Domain 4 - Reference Cells - 4-6%

- Understand the different types of reference cells, where they are used and their related conversion factors.
- Understand the construction and operation of reference cells and maintain them in a manner that will provide accurate readings.
- Understand the effects of temperature and electrolyte ion concentration on the calibration of reference cells.
- Install permanent (stationary) reference cells and check them periodically to insure they are in good working order.
- Understand the recommendations in the Safety Data Sheet pertaining to the handling and disposal of Copper Sulfate.
- Use an antimony half-cell in comparison to a copper/copper sulfate half-cell for determining the pH of soils.

Domain 5- Instruments - 2-4%

- Understand the operation of digital and analog Volt-Ohm meters (Multimeters) and how they are used to measure current, voltage and resistance.
- Understand and demonstrate other methods to measure current in CP circuits, such as, clamp-on ammeters and zero resistance ammeters.
- Use a digital Volt-Ohm meter to determine the current output of sacrificial anodes.
- Understand the various types of pipe locating instruments and be able to utilize them to locate pipelines, cables, shorts and broken cables in all underground environments.
- Understand the advantages and disadvantages of conductive and inductive pipe and cable locators.
- Understand the methods and equipment for testing pipeline coatings for holidays (damage) before burial.
- Be familiar with the use of in-line inspection tools for pipelines.

Domain 6 - CP Test Leads - 1-3%

- Install test leads for a potential test station according to common industry practice.
- Install jumper test leads across an isolation flange according to common industry practice.
- Install test leads for an interference bond

according to common industry practice.
- Install test leads for a foreign line crossing.
- Install and calibrate 2-wire and 4-wire line current test stations.
- Understand the common methods of making test lead and cable attachments to structures.
- Understand the equipment and procedures to make test lead and cable attachments to a pipe or tank by using an exothermic weld kit.
- Understand the equipment and procedures to make repairs and/or splices to bond leads, header cables and test leads.
- Understand the equipment and procedures to add additional positive or negative cables to an existing rectifier circuit.

Domain 7 - Field Tests - 13-15%

- Understand the procedure and equipment for performing and analyzing a current requirement test.
- Understand the procedure and equipment for a soil pH test.
- Understand and demonstrate the methods for correcting for IR Drop errors in structure-to-electrolyte potentials.
- Understand and demonstrate the effects of resistances in a CP measurement circuit and impedance in a Volt-Ohm meter on the true and measured potentials.
- Conduct a Wenner 4-pin soil resistivity test with a soil resistance meter or equivalent instrument and calculate the soil resistivity.
- Conduct soil resistivity measurements by using a Soil Box.
- Understand and be able to perform Barnes Layer soil resistivity calculations.
- Conduct single-point soil resistivity readings with a "Collins Rod".
- Install current interrupters in rectifiers or bonds for the purpose of taking "On" and "Instant off" structure-to-electrolyte potential readings.
- Demonstrate the different types of "shorted casing tests" on buried pipelines and casings and interpret the results of the tests regarding electrical isolation, metallic short and electrolytic couple.
- Understand the procedures and calculations for determining pipe resistance to remote earth, coating conductance and specific conductance.
- Know how to perform examinations of the coating and pipe on sections of pipeline that have been excavated.
- Understand the use of soil resistivity tests for selecting sites for installing impressed current or galvanic anodes.
- Know how to locate breaks in header cables with a "audio type" pipe and cable locator.
- Understand the basic principles of corrosion and CP testing on reinforced concrete structures.
- Analyze reinforcing-to-reference electrode potential measurement for probability of corrosion.

Domain 8 - Periodic Surveys - 1-2%

- Conduct annual structure-to-electrolyte surveys on all facilities.
- Conduct a polarization decay test.
- Conduct rectifier readings.
- Conduct surveys of bonds.
- Conduct surveys of diodes or current reversing switches.
- Conduct soil resistivity surveys.
- Conduct cell-to-cell surveys.
- Collect data on external CP coupon test stations.
- Conduct offshore platform and riser surveys.
- Be familiar with the purposes, procedures, equipment and data evaluation of the

Domain 9 - Insulators and Shorts - 1-3%

- Understand the use of electrical isolation between facilities or equipment and the advantages and disadvantages of different types of isolation devices.
- Understand the use of protective devices for isolation devices.
- Understand the effects a metallic short can have on a CP system.
- Understand the test to determine if an isolation device is shorted using pipe-to-soil potential readings.
- Understand the procedure and equipment to test the effectiveness of an isolator with an electronic isolation checking instrument.
- Understand methods and equipment used to locate and clear shorts on an underground pipeline system.

Domain 10 - Shunts - 1-2%

- Understand the procedures and calculation methods to determine the amount of current in a shunt by reading the milli-Volt (mV) drop across it with a digital voltmeter.
- Understand how to determine the direction of current in a shunt by observing the polarity of the mV reading.
- Understand how to read shunts in rectifiers to determine the output current.
- Understand how to read shunts in bonds with foreign structures and properly record the current magnitude and direction.
- Understand how to read shunts for individual anodes associated with impressed current ground beds.
- Understand how to utilize an external shunt to determine the output current of a rectifier with a broken amp meter.
- Understand how to read shunts that are installed in galvanic anodes to determine output current.

Domain 11 - DC Stray Current Interference - 6-8%

- Understand the causes and general solutions for Dynamic and Static stray current interferences.
- Understand the principles of and solutions to "Anodic" and "Cathodic" stray current situations.
- Conduct and document interference tests where stray currents are suspected and analyze the results.
- Once interference tests have been run, suggest methods of control that will mitigate the effects of the stray current.
- Understand how Line Current test stations can be used to evaluate stray current.
- Understand how Coupon Test station can be used to determine the presence of and used in the mitigation of stray current.
- Calculate the resistance required for to provide the amount of current drain desired at a resistance bond installation.

Domain 12 - AC Mitigation - 4-6%

- Understand the safety requirements when installing or working with test stations and other equipment near high voltage power lines.
- Understand the causes and types of AC interference (or interactions) with pipelines and related safety standards and safe work practices.
- Understand procedures and equipment used to mitigate the effects of excessive AC voltage induced on underground structures.
- Know the AC voltage safety limit for pipelines and how to test for it safely.
- Be able to safely test a rectifier cabinet for AC voltage before touching it.
- Understand conditions where AC corrosion can occur.

Domain 13 - Internal - 2-4%

- Collect data on Electrical Resistance (ER) probes.

Domain 14 - Atmospheric - 1-3%

- Perform periodic atmospheric corrosion inspections and document your findings according to accepted industry practice.

Domain 15 - Record Keeping and Administrative - 1-3%

- Record readings from periodic surveys and any other inspection and maintenance activities according to the common industry practice.
- Maintain all records required by the respective policy or regulation for the life of the facility involved.
- Understand the importance of accurate facility records and drawings, such as pipeline alignment sheets and other system maps and be able to provide accurate locations where work was done or new facilities installed.

Types of Questions

Description of Questions

The questions on this exam are multiple-choice and there is only one correct answer per question. The questions are based on the knowledge and skills required in the cathodic protection industry for a Cathodic Protection Technician. While the NACE training course is an excellent method of preparation, it is not the only reference used in the development of the questions. Additional references can be found in the Reference Section.

Sample Questions

The sample questions are included to illustrate the formats and types of questions that will be on the exam. Your performance on the sample questions should not be viewed as a predictor of your performance on the actual test.

1. What is the current in a 91 m (300 ft.) span of 762 mm (30 in.) pipe weighing 176.65 kg/m (118.7 lb/ft), if the voltage drop across that span is 0.62 mV?

   a. 0.850 A
   b. 1.176 A
   c. 2.802 A
   d. 2.585 A

2. What is the pipe-to-earth resistance of a 3 km (1.86 mi.) section of 32 cm (12.75 in) diameter pipe that has a 4-wire current span at each end with the following data?

Eon TS1 = -1320 mV	Eon TS2 = -1240 mV
Eoff TS1 = -1000 mV	Eoff TS2 = -1080 mV
Ion TS1 = 3.0 A	Ion TS2 = 2.6 A
Ioff TS1 = 1.0 A	Ioff TS2 = 1.0 A

a. 0.052 Ω
b. 0.076 Ω
c. 0.15 Ω
d. 0.60 Ω

3. When an ammeter with an internal resistance of 0.15 Ω is inserted into a circuit that is normally operating at 5 V and 20 A, the ammeter will read a current of:

a. 0.08 A
b. 10 A
c. 12.5 A
d. 50 A

Answer Key

1. **A**

Reference: NACE Cathodic Protection Technician (CP 2) Course Material

2. **D**

Reference: NACE Cathodic Protection Technician (CP 2) Course Material

3. **C**

Reference: NACE Cathodic Protection Technician (CP 2) Course Material

Preparation

Training

NACE Cathodic Protection Technician (CP2)- Course

Strongly Recommended Prerequisite Training

NACE Cathodic Protection Tester (CP1) – Course

Suggested Study Material

- NACE Cathodic Protection Technician (CP2) - course materials
- NACE Cathodic Protection Tester (CP1) - course materials

To take the NACE Cathodic Protection Technician (CP 2) exam without taking the NACE Cathodic Protection Technician (CP 2) course, the following materials are recommended for review. These are in addition to reference materials listed in the Exam Preparation Guide for the Cathodic Protection Tester (CP1) exam. The CP2 exam covers certain information that is contained within these documents, as well as primarily, the Cathodic Protection Technician (CP2) course material.

Books

- Peabody, A.W. (2001), Control of Pipeline Corrosion, Second edition. NACE International, the Corrosion Society.
- Holtsbaum, W. B. Cathodic Protection Survey Procedures. NACE International, the Corrosion Society, 2012
- Parker, M. and Peattie, E., Pipeline Corrosion and Cathodic Protection, Third Edition, Gulf Publishing, 1984

Papers

- Ansuini, Frank J., James R. Dimond, "Factors Affecting the Accuracy of Reference Electrodes", Materials Performance, 33, 11 (1994): pp. 14-17.
- "A Guide to Understanding Electrode Readings", Robert M. Park, Materials Performance, 2009 (NACE International, Houston, TX).

Standards

The latest editions should be used for all standards. Certain content from these standards are incorporated in the NACE Cathodic Protection Technician (CP 2) course materials and some of them are included in the course manual.

- SP0169 Control of External Corrosion on Underground or Submerged Metallic Piping Systems
- SP0285 Corrosion Control of Underground Storage Tank Systems by Cathodic Protection
- SP0388 Impressed Current Cathodic Protection of Internal Submerged Surfaces of Carbon Steel Water Storage Tanks
- SP0177 Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems

- SP0575 Internal Cathodic Protection (CP) Systems in Oil-Treating Vessels
- SP0176 Corrosion Control of Submerged Areas of Permanently Installed Steel Offshore Structures Associated with Petroleum Production
- RP0193 External Cathodic Protection of On-Grade Carbon Steel Storage Tank Bottoms
- SP0196 Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks
- SP0290 Impressed Current Cathodic Protection of Reinforcing Steel in Atmospherically Exposed Concrete Structures
- SP0200 Steel-Cased Pipeline Practices
- TM0497 Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
- TM0101 Measurement Techniques Related to Criteria for Cathodic Protection of Underground Storage Tank Systems
- TM0102 Measurement of Protective Coating Electrical Conductance on Underground Pipelines

Other

- American Water Works Association (AWWA)

  Standard D104 "Automatically Controlled, Impressed Current Cathodic Protection for the Interior of Steel Water Tanks."
- American Petroleum Institute (API)
  Recommended Practice 651, "Cathodic Protection of Above Ground Petroleum Storage Tanks.

  Recommended Practice 1632, "Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems."
- U.S. Government, Code of Federal Regulations (CFR)

  49CFR Part 192, Subpart I Natural Gas Pipelines

  49CFR Part 193, Subpart G Liquefied Natural Gas

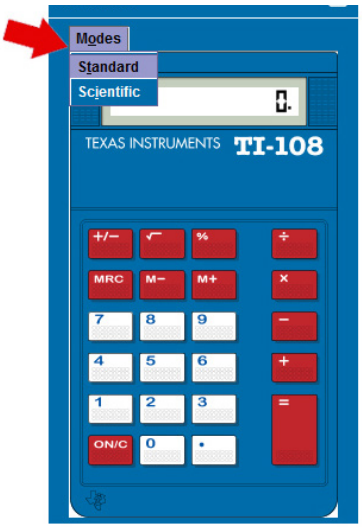
  49CFR Part 195, Subpart D Hazardous Liquid Pipelines

  40CFR Part 280 Underground Storage Tanks

Calculators

CBT exams contain a built-in calculator. Students will have access to either a TI Standard or TI Scientific calculator for use during the CBT Exam.

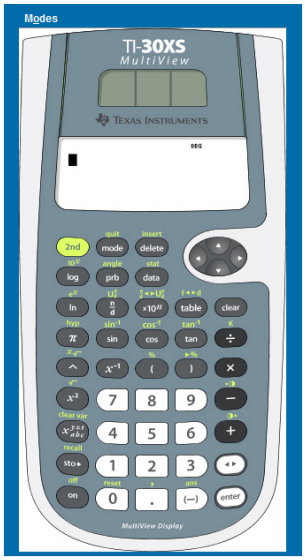
Standard Calculator



Standard Mode Functions

Add	+	
Subtract	-	
Multiply	X	
Divide	÷	
Negative	(-)	
Percentage	%	
Square Root	√	Example: 4 √
Reciprocal (Inverse)	x	Example: 1 ÷ 2 =
Store value to variable	M+	Example: 3 * 5 = M+
Access variable	MRC	Example: 7 + MRC =
Clear variable	M- MRC	

Scientific Calculator



Scientific Mode Functions

Add	+	
Subtract	-	
Multiply	X	
Divide	÷	
Negative	(-)	
Percentage	2nd [%]	
Square Root	√	Example: 2nd √ 4 enter
Reciprocal (Inverse)	X^{-1}	Example: 2 X^{-1} enter
Store value to variable	sto▶ X^{yzt}	Example: 3 * 5 enter sto▶ X^{yzt} enter
Access variable	X^{yzt} or 2nd [recall]	Example: 7 + 2nd [recall] enter enter

Numeric Notation

Standard (Floating Decimal) Notation (digits to the left and right of decimal	mode menu options **NORM** SCI ENG FLOAT 0 1 2 3 **4** 5 …	 e.g. 123456.78 e.g. 123456.7800
Scientific Notation (1 digit to the left of decimal and appropriate power of 10)	mode menu options NORM **SCI** ENG	 e.g. 1.2345678*105
Engineering Notation (number from 1 to 999 times 10 to an integer power that is a multiple of 3)	mode menu options NORM **SCI** ENG	 e.g. 123.45678*103

Fractions

Simple fractions	n/d
Mixed numbers	2nd [Un/d]
Conversion b/w simple fraction and mixed number	2nd [n/d ◀▶ Un/d]
Conversion b/w fraction and decimal	2nd [f ◀▶ d]

Powers, roots, and inverses

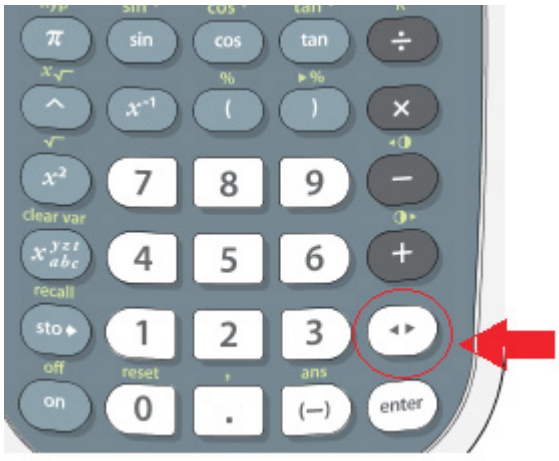
Square a value	x^2	
Cube a value	^	
Raise value to specified power	^	Example (2^4) 2 ^ 4
Square root	2nd [√]	Example (√16): 2nd [√] 16
Reciprocal	x^{-1}	Example (n^{th} root): 5^{th} root of 8: 5 2nd [^{x}√] 8

Pi

PI (π)	π

Toggle

The scientific calculator might show the results of certain calculations as a fraction - possibly involving pi or a square root. To convert this kind of result to a single number with a decimal point, you will need to use the "toggle answer" button circled in the picture below. Pressing this button will change the display from a fractional to a decimal format.



Answer Toggle

Press the ◀▶ key to toggle the display result between fraction and decimal answers, exact square root and decimal, and exact pi and decimal.

Example

Answer toggle	2nd [√] 8 enter	√8 → $2\sqrt{2}$
	◀▶	$\frac{\sqrt{8}}{2\sqrt{2}}$ → $2\sqrt{2}$ → 2.828427125

If you find this onscreen calculator difficult to use, raise your hand and ask the TA to provide you with a hand-held calculator. **If available**, you will be provided with a scientific or non-scientific calculator. Candidates are not permitted to bring their own calculator into the testing room.

Reference Material Provided During the Exam

Candidates will not have access to the full manual during the exam however targeted reference material will be available in the testing system. This material is provided during the exam to aid in answering questions. No outside material is permitted during the written exam.

- Conversions

  US to metric
  Volts
  Ampere
  Ohms
  meter

- Symbol definitions

  EMF
  E or e
  V or v
  mV or mv
  µV ar µv
  I or i
  mA or ma
  µA or µa
  R, r or Q

- Formulas

  Resistivity
  OHMS Law
  Power
  Series Circuits
  Parallel Circuits
  Area of a Circle
  Surface area of a Cylinder
  Faraday's Law
  4-Wire Line Current Test Calibration Factor
  Coating Conductance
  Rectifier Efficiency Formula
  AC Input Power
  Current Requirement Calculations

- Tables and Figures

  Shunt Types and Values
  Consumption Rate (K) for Various Metals
  Relative Values of Typical Reference Electrodes to Copper-Copper Sulfate Reference Electrode
  Steel Pipe Resistance
  Relative Values of Typical Electrodes to a Hydrogen Electrode
  Reference Electrode Conversion Scale
  4-Wire Current Span Test Station
  Meter Measurement Error
  Color Code for Resistors

Rectifier Troubleshooting Flow Diagram
Rectifier Circuit
Practical Galvanic Series in Seawater
Electrochemical Circuits
Structure-to-Electrolyte Potential
Earth Current (potential) Measurement Between Two Reference Electrodes
Forms of Corrosion