COUNTY OF ERIE

DIVISION OF PURCHASE
MEMORANDUM

To: All Using Departments

From: Jamie Kucewicz, Buyer

Date: November 25, 2024

Subject: MAINTENANCE TESTING

Bid No.: A221332-002

Effective Dates: Extended through December 31, 2027

Vendor #: 109958

Vendor: FERGUSON ELECTRIC SERVICE CO., INC.
321 Ellicott Street
Buffalo, NY 14203

Telephone: 716-853-3321

Contact: Kevin T. Roland

Pricing: per attached document

Docusign Envelope ID: 44534CC0-AB6E-433A-BE77-D98A69FF58BE

COUNTY OF ERIE

DIVISION OF PURCHASE

October 23, 2024

Ferguson Electric ~~Service Co.~~, Inc.
321 Ellicott St.
Buffalo, Ny 14203
Attn: Kevin T. Roland

Re: BID A221332-002 "Maintenance Testing"

Dear Mr. Roland,

The County of Erie wishes to extend this agreement for an additional term, through December 31, 2027 under the same prices, terms and conditions as the original agreement.

Extension is provided for per paragraph 26, Page 5 of 6 of the "Instructions to Bidders". This offer is for your immediate consideration and acceptance. Please indicate below whether you agree to extend or do not wish to extend. Please respond **within seven days upon receipt of this request.**

After approval and execution by the County, a fully signed copy will be returned to you for your files.

__X__ Yes, I agree to extend _____ No, I do not wish to extend

Please complete and submit the following if indicated by an (X) for any bid extension agreed upon:

___X__ Insurance Form __X__ Workers Compensation Form

Company Name: Ferguson Electric Inc.

Representative (Please print): Kevin P. Nugent, COO Title: _____

Signature: DocuSigned by: 70A51876F8A8491... Date: 11/21/2024

Sincerely,

James D. Kucewicz
Buyer

Vallie M. Ferraraccio
Director of Purchase

11/25/2024
DATE

COUNTY OF ERIE

MARK C. POLONCARZ
COUNTY EXECUTIVE

DIVISION OF PURCHASE

INVITATION TO BID

Bids, as stated below, will be received and publicly opened by the Division of Purchase in accordance with the attached specifications. FAX bids are unacceptable. Bids must be submitted in a sealed envelope to:

County of Erie
Division of Purchase
Attention: JAMES D. KUCEWICZ, BUYER (716) 858-6336
95 Franklin Street, Room 1254
Buffalo, New York 14202-3967

NOTE: Lower left-hand corner of envelope MUST indicate the following:

BID NUMBER: A221332-002

OPENING DATE: FEBRUARY 2, 2022 TIME: 11:00 AM

FOR: MAINTENANCE TESTING

NAME OF BIDDER: Ferguson Electric Service Co., Inc.

If you are submitting other Invitations to Bid, each bid must be enclosed in a separate envelope.

Following EXHIBITS are attached to and made a part of the bid specifications, and part of any agreement entered into pursuant to this Invitation to Bid:

X	EXHIBIT "A" - Assignment of Public Contracts
X	EXHIBIT "B" - Purchases by Other Local Governments or Special Districts
____	EXHIBIT "C" - Construction/Reconstruction Contracts
____	EXHIBIT "D" - Bid Bond (Formal Bid)
N/A	EXHIBIT "E" - Bid Bond (Informal Bid)
X	EXHIBIT "EP" - Equal Pay Certification
____	EXHIBIT "F" - Standard Agreement
X	EXHIBIT "G" - Non-Collusive Bidding Certification
X	EXHIBIT "H" - MBE/ WBE Commitment
X	EXHIBIT "IC" - Insurance CLASSIFICATION "C"
____	EXHIBIT "P" & EXHIBIT "PBI" - Performance Bond
____	EXHIBIT "Q" - Confined Space Program Certification
X	EXHIBIT "PW" - NYS Prevailing Wage
X	EXHIBIT "V" - Vendor Federal Compliance Certification

EXHIBIT "G"

County of Erie

DIVISION OF PURCHASE

NON-COLLUSIVE BIDDING CERTIFICATION

By submission of this bid, each bidder and each person signing on behalf of any bidder certifies, and in the case of a joint bid each party thereto certifies as to its own organization, under penalty of perjury, that to the best of his knowledge and belief:

(1) the prices in this bid have been arrived at independently without collusion, consultation, communication, or agreement, for the purpose of restricting competition, as to any matter relating to such prices with any other bidder or any competitor;

(2) unless otherwise required by law, the prices which have been quoted in this bid have not been knowingly disclosed by the bidder and will not knowingly be disclosed by the bidder prior to opening, directly or indirectly, to any other bidder or to any competitor; and

(3) no attempt has been made or will be made by the bidder to induce any other person, partnership or corporation to submit or not to submit a bid for the purpose of restricting competition.

NOTICE

(Penal Law, Section 210.45)

IT IS A CRIME, PUNISHABLE AS A CLASS A MISDEMEANOR UNDER THE LAWS OF THE STATE OF NEW YORK, FOR A PERSON, IN AND BY A WRITTEN INSTRUMENT, TO KNOWINGLY MAKE A FALSE STATEMENT, OR TO MAKE A FALSE STATEMENT, OR TO MAKE A STATEMENT WHICH SUCH PERSON DOES NOT BELIEVE TO BE TRUE.

BID NOT ACCEPTABLE WITHOUT FOLLOWING CERTIFICATION:

Affirmed under penalty of perjury this 2nd day of February, 20 22

TERMS Net 10 DELIVERY DATE AT DESTINATION _____

FIRM NAME Ferguson Electric Service Co., Inc.

ADDRESS 321 Ellicott Street

Buffalo, New York ZIP 14203

AUTHORIZED SIGNATURE _____

TYPED NAME OF AUTHORIZED SIGNATURE Kevin T. Roland

TITLE CEO,President TELEPHONE NO. 716-853-3321

County of Erie
DIVISION OF PURCHASE
BID SPECIFICATIONS

BID NO. A221332-002

Ship to: County of Erie
Attention: Sewer District
Address:

Ship Via: Most Economical
Date Required at Destination: As Required

ITEM NO.	QUANTITY	U/M	CATALOG NO./DESCRIPTION	TOTAL PRICE
			Vendor to perform inspections, tests and test data evaluation at	
			at Erie County Sewer District #2, 8443 Lake Shore Road,	
			Angola, NY 14006 per the attached specifications	
			Term of the contract will be January 1, 2022 – December 31, 2024	
			Yearly cost for services:	
			January 1, 2022 – December 31, 2022	$9,916.00
			January 1, 2023 – December 31, 2023	$6,020.00
			January 1, 2024 – December 31, 2024	$6,204.00

NOTE: Bid results cannot be given over the phone. All requests for bid results should be submitted in writing or faxed to:

ERIE COUNTY DIVISION OF PURCHASE
Freedom of Information Officer
95 Franklin Street, Rm. 1254
Buffalo, NY 14202
FAX #: **716/858-6465**

TOTAL BID $22,140.00

NAME OF BIDDER Ferguson Electric Service Co., Inc.

Professional Services
and
Maintenance Testing Specifications
For

Erie County Sewer District #2

CONTENTS

To perform the scope of year #1 of a 3-year program and include an infrared only inspection in years 2 & 3

STANDARD SPECIFICATION FORM

ELECTRICAL MAINTENANCE TESTS

1 General Scope

1.1 The owner shall engage the services of a recognized independent testing firm for the purpose of performing inspections, tests and test data evaluation as herein specified.

1.2 The testing firm shall provide all material , equipment, labor, temporary power, and technical supervision to perform such tests and inspections.

1.3. It is the purpose of these specifications to assure that all tested electrical equipment and systems are operational and within industry and manufacturer's tolerances.

(1) Year Electrical Preventive Maintenance Scope

- Infrared Thermographic Inspection of your facilities Electrical Distribution System (2-3 day plus report generation). In addition to certified thermographer, the testing firm will provide an additional electrician to remove and replace equipment covers.
- Visual inspection of your facilities Electrical Distribution System.
- De-energized Preventive Maintenance of the facility Main 3000 Amp draw-out circuit breaker with solid state overcurrent device. This breaker will be checked based on manufacturers recommendations for maintenance on both breaker and overcurrent device, and primary injection tested.
- De-energized Preventive Maintenance of the facility sub panel 1200 Amp circuit breaker with ground fault protection. The breaker will be checked based on manufacturers recommendations and primary injection tested.

NOTES:

1. All switching to accommodate all Electrical Preventive Maintenance Program is to be done by the testing company.

2. All utility co-ordination for required line outages is the responsibility of the testing firm.

APPLICABLE REFERENCES

2.1 Codes, Standards, and Specifications

All inspections and field tests shall be in accordance with the latest edition of the following codes, standards, and specifications except as provided otherwise herein.

1. American National Standards Institute – ANSI
2. American Society for Testing and Materials – ASTM
3. Association of Edison Illuminating Companies - AEIC
4. Canadian Standards Association - CSA
5. Electrical Apparatus Service Association – EASA
6. Institute of Electrical and Electronic Engineers - IEEE

   ANSI/IEEE C2 *National Electrical Safety Code*

   ANSI/IEEE C37 *Guides and Standards for Circuit Breakers, Switchgear, Relays, Substations, and Fuses*

   ANSI/IEEE C62 *Surge Protection*

   IEEE Std. 100 The IEEE *Standard Dictionary of Electrical and Electronics Terms*

   IEEE Std. 141 IEEE *Recommended Practice for Electrical Power Distribution for Industrial Plants (IEEE Red Book)*

   ANSI/IEEE Std. 242 IEEE *Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book)*

   ANSI/IEEE Std. 902 IEEE *Guide for Maintenance, Operation, and Safety of Industrial and Commercial Power Systems (Yellow Book)*

   IEEE Std. 1015 IEEE *Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems (Blue Book)*

7. Insulated Cable Engineers Association - ICEA
8. InterNational Electrical Testing Association - NETA

   ANSI/NETA ETT *Standard for Certification of Electrical Testing Technicians*

2. APPLICABLE REFERENCES

2.1 Codes, Standards, and Specifications (cont.)

9. National Electrical Manufacturer's Association - NEMA

   NEMA AB4 *Guidelines for Inspection and Preventive Maintenance of Molded-Case Circuit Breakers Used in Commercial and Industrial Applications*

   ANSI/NEMA 84.1 *Electrical Power Systems and Equipment Voltage Ratings (60 Hz)*

10. National Fire Protection Association - NFPA

    ANSI/NFPA 70 *National Electrical Code*

    ANSI/NFPA 70B *Recommended Practice for Electric Equipment Maintenance*

    ANSI/NFPA 70E *Electrical Safety Requirements for Employee Workplaces*

    ANSI/NFPA 101 *Life Safety Code*

11. Occupational Safety and Health Administration - OSHA

12. Scaffold Industry Association - SIA

13. State and local codes and ordinances

14. Underwriters Laboratories, Inc. – UL

2. APPLICABLE REFERENCES

2.2 Contact Information

2.2 Contact Information

American National Standards Institute – ANSI
11 West 42nd Street
New York, NY 10036
(212) 642-8902

American Society for Testing and Materials – ASTM
100 Barr Harbor Drive
W. Conshohocken, PA 19428
(610) 832-9500

AVO/Biddle Instruments
510 Township Road
Blue Bell, PA 19422
(215) 646-9200

Association of Edison Illuminating Companies – AEIC
600 N. 18th Street; PO Box 2641
Birmingham, AL 35291
(205) 257-2530

Canadian Standards Association – CSA
178 Rexdale Boulevard
Toronto, ON M9W 1R3
(416) 747-4000

Electrical Apparatus Service Association – EASA
1331 Baur Boulevard
St. Louis, MO 63132
(314) 993-2220

Institute of Electrical and Electronic Engineers – IEEE
PO Box 1331
Piscataway, NJ 08855
(908) 981-0060

Insulated Cable Engineers Association – ICEA
PO Box 440
S. Yarmouth, MA 02664
(508) 394-4424

2. APPLICABLE REFERENCES

2.2 Contact Information (cont.)

International Electrotechnical Commission – IEC
Contact through American National Standards Institute

InterNational Electrical Testing Association – NETA
PO Box 687/106 Stone Street
Morrison, CO 80465
(303) 697-8441

Marcel Dekker, Inc.
PO Box 5005
Monticello, NY 12701
(800) 228-160

National Electrical Manufacturers Association
1300 N. 17th St. Suite 1847
Rosslyn, VA 22209
(703) 841-3200

National Fire Prevention Association – NFPA
1 Battery March Park
PO Box 901
Quincy, MA 02269-9101
(617) 984-7247

Occupational Safety and Health Administration – OSHA
U.S. Department of Labor
Occupational Safety & Health Administration
Office of Public Affairs - Room N3647
200 Constitution Avenue
Washington, D.C. 20210
(202) 693-1999

Scaffold Industry Association – SIA
20335 Ventura Boulevard, #310
Woodland Hills, CA 91364
(818) 610-0320

Underwriters Laboratories, Inc. – UL
333 Pfingsten Road
Northbrook, IL 60062
(847) 272-8800

3. QUALIFICATIONS OF TESTING FIRM

3.1. The testing organization shall be an independent testing organization that is a NETA affiliate member.

3.2. The testing firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems with 10 years minimum documented experience.

3.3. The testing firm must have a full-time Field Safety Inspector that is an employee of the company. The Safety Inspector cannot be a Project Manager, Field Labor Superintendent, Job Foreman or laborer. The inspector must be full-time Safety Inspector.

3.4. The testing firm must have a full-time Electrical Professional Engineer that is an employee of the company. The Professional Engineer will be required to review, approve and stamp the final test data and recommendations that will be provided each year.

3.5. The testing firm shall utilize technicians who are regular full-time employees (minimum 2 years) employed by the firm for testing services. Hiring 3rd party test firms that are not regular employees of your company is not acceptable.

3.6 The testing firm shall submit proof of the above qualifications with the bid documents. The Lead Service Technician, Field Safety Inspector and Professional Engineer must be listed by name in the proposal.

3.7 Strict adherence to the NFPA-70E Personal Protective Equipment Standard is mandatory. Certification of NFPA-70E training within the last year, for each service technician, will be required at the time of the bid.

3.8 The testing firms thermographer must be a full-time employee of the test firm with a minimum of 3 years full-time service with the test firm as a certified thermographer. See Section #8 of this specification for additional thermographer requirements. Hiring a 3rd party thermographer is not acceptable.

3.9 Final payment will be held on this project until all of the above criteria are met including copies of safety inspections, P.E. stamps on all reports and test equipment calibration certificates no older that 12 months for each piece of test equipment used.

4. DIVISION OF RESPONSIBILITY

4.1. The testing firm will be responsible for supplying any power needed to accomplish the specified maintenance and testing.

4.2. The owner shall notify the testing firm when equipment becomes available for maintenance tests. Work shall be coordinated to expedite project scheduling.

4.3. The testing firm shall notify the owner prior to commencement of any testing.

4.4. Any system, material, or workmanship which if found defective on the basis of maintenance tests shall be reported including recommended corrective actions.

4.5. The testing firm shall maintain a written record of all tests and shall assemble and certify a final test report. The certification must be done by an Electrical P.E. (See Section 3.4 of this specification).

4.6. Safety and Precautions

1. Safety practices should include, but are not limited to, the following requirements:

    1. Current Occupational Safety and Health Organizations

    2. National Safety Council, Accident Prevention Manual for Industrial Operations

    3. Applicable state and local safety operating procedures

    4. Owner's safety practices

    5. ANSI/NFPA-70E, Electrical Safety Requirements for Employee Workplaces

    6. OSHA 29 CFR 1910/47. Council of Hazardous Energy Sources (Lockout/Tagout)

2. All tests shall be performed with apparatus de-energized except where otherwise specifically required.

3. The testing organization shall have designated safety representative on the project to supervise operations with respect to safety. (See Section 3.3 of this specification).

5. GENERAL

5.1 Suitability of Test Equipment

1. All test equipment shall be in good mechanical and electrical condition.

2. Split-core current transformers and clamp-on or tong-type ammeters require careful consideration of the following in regard to accuracy.

    1. Position of the conductor within the core

    2. Clean, tight fit of the core pole faces

    3. Presence of external fields

    4. Accuracy of the current transformer ratio in addition to the accuracy of the secondary meter.

3. Selection of metering equipment should be based on a knowledge of the waveform of the variable being measured. Digital multimeters may be average or rms sensing and may include or exclude the dc component. When the variable contains harmonics or dc offset and, in general, any deviation from a pure sine wave, average sensing, rms scaled meters may be misleading.

4. Field test metering used to check power system meter calibration must have an accuracy higher than that of the instrument being checked.

5. Accuracy of metering in test equipment shall be appropriate for the test being performed but not in excess of two percent of the scale used.

6. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and the tested equipment.

5 GENERAL

5.2 Test Instrument Calibration

1. The testing firm shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.
2. The accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).
3. Instruments shall be calibrated in accordance with the following frequency schedule:
    1. Field instruments: Analog, 6 months maximum. Digital, 12 months maximum.
    2. Laboratory instruments: 12 months maximum.
4. Dated calibration labels shall be visible on all test equipment.
5. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date and must be part of the yearly field service report.
6. Up-to-date instrument calibration instructions and procedures shall be maintained for each test instrument.
7. Calibrating standard shall be of higher accuracy than that of the instrument tested.

5.3 Test Report

1. The test report shall include the following:
    1. Summary of project.
    2. Description of equipment tested.
    3. Description of tests.
    4. Test results
    5. Analysis and recommendations.
2. Furnish a copy or copies of the complete report to the owner as required in the maintenance contract.
3. The test report must be stamped by an Electrical P.E. (Section 3.4 of this specification).

7.0 INSPECTION AND TEST PROCEDURES

7.1 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection

1. Inspect physical, electrical, and mechanical condition including evidence of moisture or corona.
2. Inspect anchorage, alignment, grounding, and required area clearances.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. Verify that fuse and/or circuit breaker sizes and types correspond to drawings and coordination study as well as to the circuit breaker's address for microprocessor-communication packages.
6. Verify that current and voltage transformer ratios correspond to drawings.
7. Inspect bolted electrical connections for high resistance using one or more of the following methods:
    1. Use of a low-resistance ohmmeter in accordance with Section 7.1.B.1.
    2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
    3. Perform a thermographic survey in accordance with Section 9.
8. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
    1. Attempt closure on locked-open devices. Attempt to open locked-closed devices.
    2. Make key exchange with all devices included in the interlock scheme as applicable.
9. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
10. Verify correct barrier and shutter installation and operation.
11. Exercise all active components.
12. Inspect mechanical indicating devices for correct operation.
13. Verify that filters are in place and/or vents are clear.
14. Perform visual and mechanical inspection of instrument transformers in accordance with Section 7.10.

15. Inspect control power transformers.

    1. Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.

    2. Verify that primary and secondary fuse ratings or circuit breakers match drawings.

    3. Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

16. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted electrical connections with a low-resistance ohmmeter in accordance with Section 7.1.A.7.1.

2. Perform insulation-resistance tests for one minute on each bus section, phase-to-phase and phase-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.

*3. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it shall be in accordance with Table 100.2. The test voltage shall be applied for one minute. Refer to Section 7.1.3 before performing test.

*4. Perform insulation-resistance tests on control wiring with respect to ground. The applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.

5. Perform electrical tests on instrument transformers in accordance with Section 7.10.

6. Perform ground-resistance tests in accordance with Section 7.13.

7. Determine accuracy of all meters and calibrate watthour meters in accordance with Section 7.11.

8. Control Power Transformers

    1. Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1

7.0 INSPECTION AND TEST PROCEDURES

7.1 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES (CONTINUED)

2. Verify correct function of control transfer relays located in switchgear with multiple power sources.

9. Verify operation of switchgear/switchboard heaters and their controller.

10. Perform system function tests in accordance with Section 8.

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.1.A.7.1)

2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.1.A.7.2)

3. Results of the thermographic survey shall be in accordance with Section 9. (7.1.A.7.3)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2. Insulation-resistance values of bus insulation should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated. Dielectric withstand voltage tests should not proceed until insulation-resistance levels are raised above minimum values.

3. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the test, the test dielectric withstand voltage specimen is considered to have passed the test.

4. Minimum insulation-resistance values of control wiring should be comparable to previously obtained results but not less than two megohms.

5. Results of electrical tests on instrument transformers should be in accordance with Section 7.10.

6. Results of ground resistance tests should be in accordance with Section 7.13.

7. Accuracy of meters should be in accordance with Section 7.11.

7.0 INSPECTION AND TEST PROCEDURES

A SWITCHGEAR AND SWITCHBOARD ASSEMBLIES (CONTINUED)

8. Control Power Transformers

1. Insulation-resistance values of control power transformers should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.

2. Control transfer relays should perform as designed.

9. Heaters should be operational.

10. Results of system function tests shall be in accordance with Section 8.

7.6.1.1 Circuit Breakers, Air, Insulated-Case/Molded-Case

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage and alignment.
3. Prior to cleaning the unit, perform as-found tests, if required.
4. Clean the unit.
5. Operate the circuit breaker to insure smooth operation.
6. Inspect bolted electrical connections for high resistance using one or more of the following methods:
    1. Use of a low-resistance ohmmeter in accordance with Section 7.6.1.1.B.1.
    2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
    3. Perform a thermographic survey in accordance with Section 9.
7. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
8. Perform adjustments for final protective device settings in accordance with coordination study provided by end user.
9. Perform as-left tests.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.1.A.6.1.
2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-toground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.
3. Perform a contact/pole-resistance test.

7.6.1.1 Circuit Breakers, Air, Insulated-Case/Molded-Case (*continued*)

*4. Perform insulation-resistance tests on all control wiring with respect to ground. The applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute. For units with solid-state components, follow manufacturer's recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup delay by primary current injection.

8. Determine instantaneous pickup current by primary injection.

*9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage test on shunt trip and close coils in accordance with Table 100.20.

11. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition.

12. Reset all trip logs and indicators.

13. Verify operation of charging mechanism.

C. **Test Values – Visual and Mechanical**

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.6.1.1.A.6.1)

2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.6.1.1.A.6.2)

3. Results of the thermographic survey shall be in accordance with Section 9. (7.6.1.1.A.6.3)

4. Settings shall comply with coordination study recommendations. (7.6.1.1.A.8)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2. Insulation-resistance values should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.

3. Microhm or dc millivolt drop values should not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.

4. Insulation-resistance values of control wiring should be comparable to previously obtained results but not less than two megohms.

5. Long-time pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times should not exceed the value shown in Table 100.7.

6. Short-time pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current tolerance band.

7. Ground fault pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current tolerance band.

8. Instantaneous pickup values of molded-case circuit breakers should fall within manufacturer's published tolerances and/or Table 100.8.

9. Pickup values and trip characteristics should be within manufacturer's published tolerances.

10. Minimum pickup voltage on shunt trip and close coils should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to Table 100.20.

11. Breaker open, close, trip, trip-free, antipump, and auxiliary features should function as designed.

12. Trip logs and indicators are reset.

13. The charging mechanism should operate in accordance with manufacturer's published data.

7.6.1.2 Circuit Breakers, Air, Low-Voltage Power

A. Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Inspect anchorage, alignment, and grounding.
3. Verify that all maintenance devices are available for servicing and operating the breaker.
4. Prior to cleaning the unit, perform as-found tests, if required.
5. Clean the unit.
6. Inspect arc chutes.
7. Inspect moving and stationary contacts for condition, wear, and alignment.
8. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
9. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's published data.
10. Inspect bolted electrical connections for high resistance using one or more of the following methods:
    1. Use of a low-resistance ohmmeter in accordance with Section 7.6.1.2.B.1.
    2. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
    3. Perform a thermographic survey in accordance with Section 9.
11. Verify cell fit and element alignment.
12. Verify racking mechanism operation.
13. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
14. Perform adjustments for final protective device settings in accordance with coordination study provided by end user.
15. Perform as-left tests.
16. Record as-found and as-left operation counter readings.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.2.A.10.1.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-toground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1.

3. Perform a contact/pole-resistance test.

*4. Perform insulation-resistance tests on all control wiring with respect to ground. The applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup current by primary current injection.

*9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage test on shunt trip and close coils in accordance with Table 100.20.

11. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition.

12. Reset all trip logs and indicators.

13. Verify operation of charging mechanism.

7.6.1.2 Circuit Breakers, Air, Low-Voltage Power (*continued*)

C. Test Values – Visual and Mechanical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. (7.6.1.2.A.10.1)

2. Bolt-torque levels should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.12. (7.6.1.2.A.10.2)

3. Results of the thermographic survey shall be in accordance with Section 9. (7.6.1.2.A.10.3)

4. Settings shall comply with coordination study recommendations. (7.6.1.2.A.15)

5. Operations counter should advance one digit per close-open cycle. (7.6.1.2.A.16)

D. Test Values – Electrical

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2. Insulation-resistance values of breakers should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations should be investigated.

3. Microhm or dc millivolt drop values should not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.

4. Insulation-resistance values of control wiring should be comparable to previously obtained results but not less than two megohms.

5. Long-time pickup values should be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band.

6 Short-time pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current tolerance band.

7. Ground fault pickup values should be as specified, and the trip characteristic should not exceed manufacturer's published time-current tolerance band.

8. Instantaneous pickup values should be within the tolerances of manufacturer's published data.

7.6.1.2 Circuit Breakers, Air, Low-Voltage Power (*continued*)

9. Pickup values and trip characteristic should be as specified and within manufacturer's published tolerances.

10. Minimum pickup voltage on shunt trip and close coils should be in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to Table 100.20.

11. Auxiliary features should operate in accordance with manufacturer's published data.

12. Trip logs and indicators are reset.

13. The charging mechanism should operate in accordance with manufacturer's published data.

8. SYSTEM FUNCTION TESTS

8.1 System Function Tests

1. Perform system function tests upon completion of equipment tests as defined in Section 7. It is the purpose of system function tests to prove the correct interaction of all sensing, processsing, and action devices.

2. Implementation

    1. Develop test parameters for the purpose of evaluating performance and all integral components and their functioning as a complete as a complete unit within design requirements and manufacturer's published data.

       Perform these tests.

    2. Verify the correct operation of all interlock safety devices for fail-safe functions in addition to design function.

    3. Verify the correct operation of all sensing devices, alarms, and indicating devices.

9. THERMOGRAPHIC SURVEY

Equipment to be inspected shall include all current-carrying devices.

9.1 Visual and Mechanical Inspection

1. Inspect physical and mechanical condition.
2. Remove all necessary covers prior to thermographic inspection. Use appropriate caution, safety devices, and personal protective equipment.

9.2 Equipment to be inspected shall include all current-carrying devices.

9.3 Provide report including the following:

1. Each reported thermographic image must be date and time stamped.
2. The following items must be identified for each thermographic image.
    1. Location of equipment
    2. Description of the reported component including part numbers
    3. Break, fuse or switch sizes including all relevant values including voltage, amperage, phase, coil ratings, etc.
    4. Current reading at the time the image was taken.
    5. Wire size on bus size to and from the device being reported.
    6. An observation outlining what is specifically wrong with the reported component.
    7. Specific repair or replacement recommendations.
    8. Temperature differential between deficient areas and reference areas.
    9. Repair priority ratings.
    10. Photographs both thermal and digital of the reported areas with the deficiencies clearly identified.
    11. A summary sheet shall be supplied for management of repairs. The summary sheet must include:
        1. All deficient equipment
        2. The location of each piece of equipment
        3. The repair priority of each piece of equipment
        4. An area for the signature of the repair electrician

9. THERMOGRAPHIC SURVEY (Con't)

5. An area for the date that the repair was made.

6. An area for the description of the completed repairs.

9.4 Test Parameters

1. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1°C at 30°C.

2. Equipment shall detect emitted radiation and convert detected radiation to visual signal.

3. Thermographic surveys should be performed during periods of maximum possible loading but not less than 40 percent of rated load of the electrical equipment being inspected. Refer to ANSI/NFPA 70B, Section 18-16 (Infrared Inspection).

9.5 Test Results

Suggested actions based on temperature rise can be found in Table 10.18.

9.6 Thermographic Qualifications

1. The thermographer must have the following minimum qualifications:

    1. Level 2 Certified Thermographer
    2. Journeyman Electrician
    3. Certified to work with and in the area of exposed equipment including required safety and operations training.

Note:

1. The thermographer and cover removal electricians must have and wear, when applicable, proper safety clothing, high voltage suite and face shields as defined by NFPA-70E.
2. **Exceptions to 9.6.1 will not be accepted.**

TABLE 10.1

Insulation Resistance Test Values
Electrical Apparatus and Systems Other Than Rotating Machinery

Nominal Rating of Equipment (Volts)	Minimum Test Voltage (DC)	Recommended Minimum Insulation Resistance (Megohms)
250	500	25
600	1,000	100
1,000	1,000	100
2,500	1,000	500
5,000	2,500	1,500
8,000	2,500	2,500
15,000	2,500	5,000
25,000	5,000	10,000
34,000	5,000	100,000
46,000 and above	5,000	100,000

In the absence of consensus standards dealing with insulation-resistance tests, the NETA Standards Review Council suggests the above representative values.

See Table 100.14 for temperature correction factors.

Test results are dependent on the temperature of the insulating material and the humidity of the surrounding environment at the time of the test.

Insulation-resistance test data may be used to establish a trending pattern. Deviations from the baseline information permit evaluation of the insulation.

For rotating machinery insulation-resistance test values, refer to Table 10.11

TABLE 10.2

Switchgear Withstand Test Voltages

Type of Switchgear	Rated Maximum Voltage (kV) (rms)	Maximum Test Voltage (kV)	
		AC	DC
Low-Voltage Power Circuit Breaker Switchgear	254/.508/.635	1.6	2.3
Metal-Clad Switchgear	4.76	14	20
	8.25	27	37
	15.0	27	37
	27.0	45	a
	38.0	60	a
Station-Type Cubicle Switchgear	15.5	37	a
	38.0	60	a
	72.5	120	a
Metal-Enclosed Interrupter Switchgear	4.76	14	20
	8.25	19	27
	15.0	27	37
	27	45	a
	38.0	60	a

Derived from ANSI/IEEE C37.20.1-1993 *Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear*, Paragraph 5; ANSI/IEEE C37.20.2-1999, *Standard for Metal-Clad Switchgear*, Paragraph 6.5; and ANSI/IEEE C37.20.3-2001 *Standard for Metal-Enclosed Interrupter Switchgear*, Paragraph 6.5. This table includes 0.75 multiplier with fraction rounded down.

The column headed "DC" is given as a reference only for those using dc tests to verify the integrity of connected cable installations without disconnecting the cables from the switchgear. It represents values believed to be appropriate and approximately equivalent to the corresponding power frequency withstand test values specified for voltage rating of switchgear. The presence of this column in no way implies any requirement for a dc withstand test on ac equipment or that a dc withstand test represents an acceptable alternative to the low-frequency withstand tests specified in these specifications, either for design tests, production tests, conformance tests, or field tests. When making dc tests, the voltage should be raised to the test value in discrete steps and held for a period of one minute.

a. Because of the variable voltage distribution encountered when making dc withstand tests, the manufacturer should be contacted for recommendations before applying dc withstand tests to the switchgear. Voltage transformers above 34.5 kV should be disconnected when testing with dc. Refer to ANSI/IEEE C57.13-1993 (*IEEE Standard Requirements for Instrument Transformers*) paragraph 8.8.2.

TABLE 10.7

Molded-Case Circuit Breakers
Inverse Time Trip Test
(At 300% of Rated Continuous Current of Circuit Breaker)

Range of Rated Continuous Current (Amperes)	Maximum Trip Time in Seconds for Each Maximum Frame Rating [a]	
	≤ 250 V	251 – 600 V
0-30	50	70
31-50	80	100
51-100	140	160
101-150	200	250
151-225	230	275
226-400	300	350
401-600	- - - - -	450
601-800	- - - - -	500
801-1000	- - - - -	600
1001 - 1200	- - - - -	700
1201-1600	- - - - -	775
1601-2000	- - - - -	800
2001-2500	- - - - -	850
2501-5000	- - - - -	900
6000	- - - - -	1000

Derived from Table 5-3, NEMA Standard AB 4-2000, *Guidelines for Inspection and Preventative Maintenance of Molded-Case Circuit Breaker Used in Commercial and Industrial Applications*

a. Trip times may be substantially longer for integrally-fused circuit breakers if tested with the fuses replaced by solid links (shorting bars).

TABLE 10.8

Instantaneous Trip Tolerances for Field Testing of Circuit Breakers

		Tolerances of Manufacturer's Published Trip Range	
Breaker Type	**Tolerance of Settings**	**High Side**	**Low Side**
Electronic Trip Units [1]	±30%	- - - - -	- - - - -
Adjustable [1]	+40% -30%	- - - - -	- - - - -
Nonadjustable [2]	- - - - -	+25%	-25%

NEMA AB4-2009 *Guidelines for Inspection and Preventative Maintenance of Molded-Case Circuit Breaker Used in Commercial and Industrial Applications, Table 4*

1. Tolerances are based on variations from the nominal settings.
2. Tolerances are based on variations from the manufacturer's published trip band (i.e., -25% below the low side of the band; +25% above the high side of the band.)

TABLE 10.12.1

Bolt-Torque Values for Electrical Connections

US Standard Fasteners [a]
Heat-Treated Steel – Cadmium or Zinc Plated [b]

Grade	SAE 1&2	SAE 5	SAE 7	SAE 8
Head Marking				
Minimum Tensile (Strength) (lbf/in^2)	64K	105K	133K	150K
Bolt Diameter (Inches)	**Torque (Pound-Feet)**			
1/4	4	6	8	8
5/16	7	11	15	18
3/8	12	20	27	30
7/16	19	32	44	48
1/2	30	48	68	74
9/16	42	70	96	105
5/8	59	96	135	145
3/4	96	160	225	235
7/8	150	240	350	380
1.0	225	370	530	570

a. Consult manufacturer for equipment supplied with metric fasteners.
b. Table is based on national coarse thread pitch.

Table 10.12.2

US Standard Fasteners [a]
Silicon Bronze Fasteners [b c]
Torque (Pound-Feet)

Bolt Diameter (Inches)	Nonlubricated	Lubricated
5/16	15	10
3/8	20	15
1/2	40	25
5/8	55	40
3/4	70	60

a. Consult manufacturer for equipment supplied with metric fasteners.
b. Table is based on national coarse thread pitch.
c. This table is based on bronze alloy bolts having a minimum tensile strength of 70,000 pounds per square inch.

TABLE 10.12.3

US Standard Fasteners [a]
Aluminum Alloy Fasteners [b c]
Torque (Pound-Feet)

Bolt Diameter (Inches)	Lubricated
5/16	10
3/8	14
1/2	25
5/8	40
3/4	60

a. Consult manufacturer for equipment supplied with metric fasteners.

b Table is based on national coarse thread pitch.

c. This table is based on aluminum alloy bolts having a minimum tensile strength of 55,000 pounds per square inch.

TABLE 10.12.4

US Standard Fasteners [a]
Stainless Steel Fasteners [b c]
Torque (Pound-Feet)

Bolt Diameter (Inches)	Uncoated
5/16	15
3/8	20
1/2	40
5/8	55
3/4	70

a. Consult manufacturer for equipment supplied with metric fasteners.

b. Table is based on national coarse thread pitch.

c. This table is to be used for the following hardware types:
Bolts, cap screws, nuts, flat washers, locknuts (18-8 alloy)
Belleville washers (302 alloy).

Tables in 100.12 are compiled from Penn-Union Catalogue and Square D Company, Anderson Products Division, *General Catalog*: Class 3910 *Distribution Technical Data, Class 3930 Reference Data Substation Connector Products.*

TABLE 10.14.1

Insulation Resistance Conversion Factors (20° C)

Temperature		Multiplier	
° C	° F	Apparatus Containing Oil Immersed Insulation	Apparatus Containing Solid Insulation
-10	14	0.125	0.25
-5	23	0.180	0.32
0	32	0.25	0.40
5	41	0.36	0.50
10	50	0.50	0.63
15	59	0.75	0.81
20	68	1.00	1.00
25	77	1.40	1.25
30	86	1.98	1.58
35	95	2.80	2.00
40	104	3.95	2.50
45	113	5.60	3.15
50	122	7.85	3.98
55	131	11.20	5.00
60	140	15.85	6.30
65	149	22.40	7.90
70	158	31.75	10.00
75	167	44.70	12.60
80	176	63.50	15.80
85	185	89.789	20.00
90	194	127.00	25.20
95	203	180.00	31.60
100	212	254.00	40.00
105	221	359.15	50.40
110	230	509.00	63.20

Derived from Megger, *Stitch in Time. The Complete Guide to Electrical Insulation Testing.*

Formula:

$R_c = R_t \times K$

Where: R_c is resistance corrected to 20° C

R_t is measured resistance at test temperature

K is applicable multiplier

Example: Resistance test on oil-immersion insulation at 104° F

R_t = 2 megohms @ 104° F

K = 3.95

$R_c = R_t \times K$

$R_c = 2.0 \times 3.95$

R_c = 7.90 megohms @ 20° C

TABLE 10.14.2

Insulation Resistance Conversion Factors (40° C)

Temperature		Multiplier	
° C	° F	Apparatus Containing Oil Immersed Insulation	Apparatus Containing Solid Insulation
-10	14	0.03	0.10
-5	23	0.04	0.13
0	32	0.06	0.16
5	41	0.09	0.20
10	50	0.13	0.25
15	59	0.18	0.31
20	68	0.25	0.40
25	77	0.35	0.50
30	86	0.50	0.63
35	95	0.71	0.79
40	104	1.00	1.00
45	113	1.41	1.26
50	122	2.00	1.59
55	131	2.83	2.00
60	140	4.00	2.52
65	149	5.66	3.17
70	158	8.00	4.00
75	167	11.31	5.04
80	176	16.00	6.35
85	185	22.63	8.00
90	194	32.00	10.08
95	203	45.25	12.70
100	212	64.00	16.00
105	221	90.51	20.16
110	230	128.00	25.40

Derived from Megger, *Stitch in Time... The Complete Guide to Electrical Insulation Testing* and ANSI/IEEE 43-2000 *IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery*.

Notes: The insulation resistance coefficient is based on the halving of the insulation resistance to the change in temperature.

Apparatus Containing Immersed Oil Insulation Table uses 10° C change with temperature halving.

Apparatus Containing Solid Insulation Table uses 15° C change with temperature halving.

Formula:

$R_c = R_a \times K$

Where: R_c is resistance corrected to 40° C

R_a is measured resistance at test temperature

K is applicable multiplier

Example: Resistance test on oil-immersion insulation at 68° F/20° C

R_a = 2 megohms @ 68° F/20° C

K = 0.40

$R_c = R_a \times K$

R_c = 2.0 x 0.40 = 0.8 megohms @ 40° C

TABLE 10.18

Thermographic Survey
Suggested Actions Based on Temperature Rise

Temperature difference (ΔT) based on comparisons between similar components under similar loading	Temperature difference (ΔT) based upon comparisons between component and ambient air temperatures	Recommended Action
1° C - 3° C	1° C – 10° C	Possible deficiency; warrants investigation
4° C - 15° C	11° C – 20° C	Indicates probable deficiency; repair as time permits
. . . . .	21° C – 40° C	Monitor until corrective measures can be accomplished
>15° C	>40° C	Major discrepancy; repair immediately

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables) there are various temperature ratings. Heating is generally related to the square of the current; therefore, the load current will have a major impact on ΔT. In the absence of consensus standards for ΔT, the values in this table will provide reasonable guidelines.

An alternative method of evaluation is the standards-based temperature rating system as discussed in Section 8.9.2, Conducting an IR Thermographic Inspection, *Electrical Power Systems Maintenance and Testing* by Paul Gill, PE, 1998.

It is a necessary and valid requirement that the person performing the electrical inspection be thoroughly trained and experienced concerning the apparatus and systems being evaluated as well as knowledgeable of thermographic methodology