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October 1993
QA Inspections Via Condition Monitoring

Guidelines for Quality Assurance Inspection of Commercial Activities Contracts for Real Property Maintenance Activities

Guide #4: Electrical Systems

by
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A Quality Assurance (QA) Program allows the Army to evaluate and document a contractor's work performance. It depends on a QA Surveillance Plan (QASP). The QASP, which is based on the contract Performance Work Statement, lists contractor activities and the surveillance approach, number of items to be inspected, and an Acceptable Quality Level (AQL) for each activity. This series of 12 guides will help the Contracting Officer's Representative/Quality Assurance Evaluator by defining and clarifying the inspection tasks required by the QASP, which will facilitate inspection uniformity and effectiveness.

This guide discusses QA monitoring of electrical supply stations and distribution systems.

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FOREWORD

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**GUIDELINES FOR QUALITY ASSURANCE INSPECTION OF COMMERCIAL ACTIVITIES
CONTRACTS FOR REAL PROPERTY MAINTENANCE ACTIVITIES
GUIDE #4: ELECTRICAL SYSTEMS**

1 INTRODUCTION

Background

A Quality Assurance (QA) program allows the Army to evaluate and document a contractor's performance. The Quality Assurance Evaluator (QAE) conducts skilled and carefully planned inspections aimed at verifying the satisfactory completion of contractor work. The inspections evaluate the quality, quantity, and timeliness of the services provided, not the contractor's methods used in performing the work. A good QA program promotes the best possible product within the terms of the standing contract.

A well organized QA program depends on a QA Surveillance Plan (QASP), which is prepared by the Government and contains the purpose and methods of the QA program. Although the QASP is not a part of the contract, it is based on the contract Performance Work Statement, which is part of the contract. The QASP lists contractor activities and the surveillance approach, approximate number of items to be surveyed, and an Acceptable Quality Level (AQL) for each activity.

The installation Director of Public Works (DPW), the Contracting Officer (KO), or the Contracting Officer's Representative (COR) often oversees the QASP. The COR/QAE needs an inspection guide to help define and clarify the inspection tasks required by the QASP, and to facilitate inspection uniformity and effectiveness. To meet this need, the U.S. Army Construction Engineering Research Laboratories (USACERL) developed this series of 12 inspection guides.

Objective

This guide series is intended to supplement any existing QASP and to provide QA guidance for evaluating Operations and Maintenance (O&M) work as performed by contractors on Army property. This electrical system guide contains recommended surveillance methods that can be amended by direction of the KO or QA management to fit the needs of a specific installation.

Guide Series Organization

This series includes the following guides by USACERL published in October 1993:

- #1: Water Systems (Special Report [SR] FF-94/01)
- #2: Wastewater Systems (SR FF-94/02)
- #3: Natural Gas Distribution Systems (SR FF-94/03)
- #4: **Electrical Systems**
- #5: Heating Systems (SR FF-94/05)
- #6: Ventilation, Air Conditioning, and Refrigeration Systems (SR FF-94/06)
- #7: Building Services (SR FF-94/07)
- #8: Grounds Maintenance (SR FF-94/08)
- #9: Surfaced Areas (SR FF-94/09)

2 GENERAL QA INSPECTION INFORMATION

Inspection Organization and Planning

According to custom and standard practice, the contractor submits copies of the previous month's O&M activities and regulatory agency reports to the COR and the QAE. The due dates of these reports control the start of inspection scheduling. If possible, the QAE's inspection should be conducted within 3 days after receiving the reports. Effective coordination will allow more efficient inspection of services. The COR/QAE should look for specific indicators of the contractor's performance and should evaluate that performance based on Detailed Inspection Tasks. The following chapter lists the Performance Indicators and Detailed Inspection Tasks for electrical systems.

This guide divides electrical system equipment into two categories: electrical supply stations and electrical distribution systems.

Equipment associated with electrical supply stations include:

- Power transformers
- Voltage regulators
- Circuit breakers (e.g., air, oil, vacuum, gas)
- Automatic circuit reclosers (oil, vacuum)
- Disconnect switches (e.g., single pole and group operated)
- Enclosed switches (e.g., air, oil, vacuum, gas)
- Power fuses
- Instrument transformers (e.g., current, voltage)
- Surge arresters
- Capacitor banks
- Substation structures and buses
- Switchgear and switchboards
- Protective relays
- Meters
- Storage batteries.

Equipment associated with electrical distribution systems include:

- Overhead distribution lines
- Underground cables
- Power poles, manholes, and duct banks
- Distribution transformers
- Insulators
- Grounding systems
- Pad-mounted switches
- Emergency generators.

Common contract requirements for the operation and maintenance of electrical distribution systems include:

1. Operations and Maintenance Management

a. **Work Control.** Maintain daily schedule and annual maintenance schedule, receive and schedule work requests, maintain filing and recording system, prepare documentation or markup drawings, and keep an inspection log.

b. **Project Planning.** Schedule and complete work items.

c. **Maintain Equipment Files.** Include manufacturer's literature, warranty information, and maintenance and repair history.

d. **GFE Files.** Maintain equipment files on each accountable item.

e. **Quality Control.** Provide evidence of effective quality control to ensure that all work meets contract requirements.

2. **Equipment Operation.** Maintain operating logs and operating log file for a minimum of 5 years.

3. **Equipment Maintenance.** Maintain the parts of the electrical distribution system in working condition.

4. **Contractor Reports**

a. Quality control plan

b. Inspection logs

c. Maintenance data

d. Inventory listing

e. Markup drawings

f. Warranty data.

Quality Assurance Surveillance Methods

The QAE can use the following five surveillance methods to determine contractor performance:

1. Random Sampling

2. Planned Sampling

3. 100 Percent Inspection

4. Unscheduled Inspection

5. Customer Complaints.

Random Sampling

The methods are based on statistical criteria provided in Military Standard (MIL-STD)-105E, *Sampling Procedures and Tables for Inspection by Attributes* (10 May 1989) and are presented as recommendations. The methods used should be based on the unique needs of an individual system. Generally, all five methods are not used to evaluate an individual system.

Random sampling is recommended for situations where many work items are candidates for inspection. For instance, because it is impractical to inspect every roof on an installation with 500 buildings, only a select number of the buildings should be inspected. Likewise, in random sampling, only a portion of the total performed work is inspected. Acceptance of the work is based on the assumption that the inspected items are representative of the quality of the contractor's work. The random

sampling technique spreads the selected samples evenly throughout the evaluation period. The following are steps to be used by the QAE in random sampling.

Tables A1 and A2 in Appendix A should be used to determine the number of samples to be inspected and the number of rejects allowed as a function of the number of inspected work items for AQLs of 4 and 10 percent, and the level of surveillance. The three levels of surveillance are: normal, increased (tightened), and reduced. Initially, this guide recommends normal surveillance for random sampling. However, under the direction of the KO, the level of surveillance can be changed depending on the contractor's performance.

As an example, assume that the contractor's total scheduled output (i.e., population size) for a particular work item is 125 units and that the normal surveillance level with an AQL of 4 percent has been selected. According to Table A1, 20 of the 125 units of work should be inspected, and the entire output of 125 units should be rejected if 3 or more of the 20 sample units are not acceptable.

The QA Worksheets in Appendix B provide room to record the population size, the number of samples, the maximum number of rejects, and the interval for each Performance Indicator.

The work planned by the contractor for each maintenance task should be listed by date to make it easier to predict the time when the work samples will be ready for inspection.

Planned Sampling

Evaluation by planned sampling inspects some, but not all, of the work activities and is appropriate when the number of work items is large. Some items are evaluated before scheduled completion because they are inaccessible after the work is completed. The COR/QAE subjectively selects key work items for inspection; the sample size is determined arbitrarily.

The COR/QAE will normally use planned sampling when the contractor's performance at selected locations or tasks is poor. With this type of evaluation, the contractor knows that work performed in these areas is more likely to be monitored. Planned sampling provides a systematic way of focusing on specific output and forming conclusions about the contractor's performance level.

100 Percent Inspection

Inspection at 100 percent requires total inspection of all items in a contract requirement. It is normally used to monitor infrequent work or critical contract work when the number of work items is small and in cases where nonperformance could seriously damage Army-furnished equipment or processes. It may also be used in areas where a contractor has had prior performance difficulties.

Unscheduled Inspection

Unscheduled inspections can be used for areas of poor past contractor performance, noncritical areas, areas of infrequent repairs, or as a follow-up check of previous inspections. If the QAE notices such an area, an unscheduled inspection can be conducted to evaluate contractor performance.

Customer Complaints

The customer complaint method is based on an informed and cooperative customer population, that is generally aware of local contract requirements. Customers are expected to monitor contractor services and, when performance is poor or nonexistent, to notify the COR/QAE. If investigation reveals that the

complaint is valid, the COR/QAE documents the deficiency. Since this is a reactive QA inspection approach, this method of surveillance normally supplements planned inspection methods.

Increased Surveillance

For areas of poor past contractor performance, the QAE should consult with the KO to intensify the surveillance method. More than one option is usually available, and selection should be based on the initial method and the amount of work performed.

1. Random Sampling (Normal Surveillance) can be replaced by:
 - Random Sampling (Increased Surveillance)
 - Planned Sampling (for a large population size)
 - 100 Percent Inspection (for a small population size)
 - Unscheduled Inspection (for any population size).

2. Planned Sampling can be replaced by:
 - Random Sampling (Normal Surveillance)
 - 100 Percent Inspection (for a small population size)
 - Unscheduled Inspection (for any population size).

3. Unscheduled Inspections can be replaced by:
 - 100 Percent Inspection (for a small population size)
 - Random Sampling (Normal Surveillance)
 - Planned Sampling.

Decreased Surveillance

For work areas in which the contractor maintains a consistently satisfactory performance for 3 to 6 months, the QAE should consult with the KO to decrease the intensity of the surveillance. More than one option is usually available and selection should be based on the initial method and the amount of work performed.

1. Random Sampling (Normal Surveillance) can be replaced by:
 - Random Sampling (Reduced Surveillance)
 - Planned Sampling
 - Unscheduled Inspection (for any population size)
 - Customer Complaints.

2. Planned Sampling can be replaced by:
 - Unscheduled Inspection (for any population size)
 - Customer Complaints.

3. 100 Percent Inspection can be replaced by:

- Random Sampling (Normal Surveillance)
- Random Sampling (Reduced Surveillance)
- Planned Sampling
- Unscheduled Inspection (for any population size)
- Customer Complaints.

3 ELECTRICAL SYSTEMS QA INSPECTIONS

Electrical Supply Station Operations

Performance Indicators and Detailed Inspection Tasks

The following numeric items are performed by the contractor. The related detailed inspection tasks are used by the QAE to verify the contractor's performance.

1. The logs and checklists are complete, legible, and timely.

Verify that the contractor's logs and checklists are complete, legible, and timely. Check to see that documentation includes:

- a. Dates and the initials of the person(s) who did or accepted the work.
- b. Description of the normal operation of the electrical supply stations including copies of meter readings.
- c. Reports of corrective actions taken during system outages, equipment failures, overloading, overheating, or other system failures.
- d. Recommended improvements to the electrical supply stations that will increase performance and recommended repairs to damaged or deteriorated components.

Verify that the contractor's reports are furnished on forms approved by the KO. If any reports are incomplete and the contractor does not justify the omissions (such as supporting schedules for infrequently required operations), consider the documentation to be unsatisfactory.

2. The power outage records are complete.

Review the contractor's electrical system outage records, comparing the contractor's performance with historical data, and look for any adverse performance trends. Verify that the outage records include the following:

- Date and time of outage
- Time outage was reported
- Who reported the outage
- Who took the report
- Portion of system affected
- Repair crew assigned and time
- Repair action taken
- Time service was restored
- Cause of outage
- Additional corrective action required or recommended.

3. "As-built" drawings are updated with changes and corrections.

Verify that the contractor is maintaining current "as-built" drawings of electrical supply station system facilities and equipment. Check to see that the drawings are updated annually with all

changes and corrections. The draftperson's initials and the date should accompany each change.

4. An adequate library of equipment manufacturers' manuals is being maintained.

Verify that the contractor maintains an adequate library of manufacturers' manuals for equipment and facilities. Manuals should be obtained for newly installed equipment, and obsolete manuals should be discarded.

Recommended Surveillance Approach

- Evaluate performance indicators #1 and #2 monthly using the 100 percent inspection method.
- Evaluate performance indicators #3 and #4 annually using the 100 percent inspection method.

Electrical Supply Station Maintenance

Performance Indicators and Detailed Inspection Tasks

The following numeric items are performed by the contractor. The related detailed inspection tasks are used by the QAE to verify the contractor's performance.

1. The Preventive Maintenance Inspection (PMI) report is complete, legible, and timely.

Verify that the contractor's PMI report is complete, timely, and covers all electrical supply station components. Document any discrepancies between the QAE inspection and the contractor's PMI report.

2. The Preventive Maintenance (PM) report is complete, legible, and timely.

Verify that the contractor's PM report is complete, timely, and covers all electrical supply station components. Document any discrepancies between the QAE inspections and the contractor's PM report.

Evaluate the site's PM program using the following indicators:

- a. A PM program should include the following:

- (1) Description of the specific maintenance program
- (2) Date when maintenance was performed and when it should be performed next
- (3) Special procedures or requirements to be followed
- (4) Sampling and testing requirements for insulating oil
- (5) Infrared inspection of buses and connections.

- b. Compare the frequency and cost of required repairs with historical records of the electrical supply station to further evaluate the contractor's effectiveness. If the interval between

equipment repairs is decreasing significantly, notify the KO. If historical data is not available, start a repair file on each major component for future reference.

c. Accurate and complete property records are essential for proper evaluation of PM programs, and should include:

- (1) Description of the item and its location
- (2) Manufacturer, type, serial number
- (3) Ratings
- (4) Date installed
- (5) Tests performed when installed
- (6) Description and date of any subsequent tests, maintenance, repairs, etc.

3. On-site inspections of the electrical supply stations verify satisfactory PM performance.

Conduct on-site inspections of electrical supply stations to verify that PM is adequate. Check that the contractor establishes a specific method of recording data on forms that index inspection sheets to map locations and a maintenance log to document inspection maintenance and repairs. Schedule the inspection so that the contractor may be present. Document any discrepancies between the QAE inspection and the contractor's PMI report.

Evaluate the site's operations and conditions using the following indicators:

- a. General. The overall appearance of the buildings, yard, and grounds should be attractive. Grassed areas around the building should be mowed and trimmed.
- b. Painting and Galvanizing. Buildings and steel structures should be painted or galvanized and free of rust and peeling, deteriorated paint. Equipment tanks and enclosures should be painted or galvanized and rust-free. QA instrumentation (Johnson 1993) is recommended to check for corrosion and paint condition.
- c. Fencing. Fence and gates should be intact, secure, and with danger signs in place.
- d. Surfacing. Crushed rock surfacing should be clean and complete.
- e. Oil Leaks. There should be no evidence of oil leaks in the equipment. QA instrumentation (Johnson 1993) is recommended to check oil leaks.
- f. Grounding System. Ground leads should be intact and properly supported.
- g. Porcelain. Porcelain bushings and insulators should be clean and free of chips or broken areas.
- h. Buses and Conductors. There should be no bird nests or foreign material on or near energized conductors or in transformer radiators. QA instrumentation (Johnson 1993) is recommended to detect abnormally high operating temperatures.

i. **Oil Levels.** Oil levels and temperatures in equipment should be within acceptable limits. QA instrumentation (Johnson 1993) is recommended to check for abnormally high operating temperatures.

j. **Lighting.** All lamps should work.

k. **Switchgear and Switchboards.** Areas around switchboards should be clean. Indicator lights should match position shown on circuit-breaker indicating targets. Targets on protective relays should be reset. Abnormally high operating temperatures should not be detected. QA instrumentation (Johnson 1993) is recommended to check for high operating temperatures.

l. **Circuit breaker counters.** Counter readings should correspond to readings on log sheets. Abnormally high operating temperatures should not be detected. QA instrumentation (Johnson 1993) is recommended to check for high operating temperatures.

m. **Batteries.** The battery area should be clean, and electrolyte levels should be within acceptable limits.

4. The contracted Service Order (SO) and Individual Job Order (IJO) work was done in a timely, effective, and professional manner.

Verify that contracted SO and IJO work was done in a timely, effective, and professional manner. The overall quality and appearance of the repair, including materials, must be comparable to the facility's original construction quality and appearance. Document any discrepancies between the QAE inspection and the contractor's report of work completed.

Visit the site of the selected repair to verify that the work is being performed with minimal service interruptions. After completion of the repair work, check to see that the construction area is clear of debris and that excavated areas are graded to match the surrounding area. Plan an unscheduled visit to the site later to see that excavated areas that have settled are reshaped.

Recommended Surveillance Approach

- Evaluate performance indicators #1 and #2 monthly using the 100 percent inspection method.
- Evaluate performance indicator #3 monthly using random sampling (normal surveillance, 10 percent AQL).
- For performance indicator #4, evaluate SOs monthly using random sampling (normal surveillance, 4 percent AQL) and questionnaire feedback, and evaluate IJOs monthly using the 100 percent inspection method.

Electrical Distribution System Operations

Performance Indicators and Detailed Inspection Tasks

The following numeric items are performed by the contractor. The related detailed inspection tasks are used by the QAE to verify the contractor's performance.

1. The inspection and operations records for distribution equipment are complete, legible, and timely.

Verify that the contractor's PMI and operations records for distribution equipment are complete, legible, and timely. Check to see that documentation includes:

- a. Dates and the initials of the person(s) who did or accepted the work.
- b. The description of normal inspection, operation, and maintenance of the electrical distribution equipment.
- c. Reports of corrective actions taken during system outages, equipment failure, overloading, overheating, or other system problems.
- d. Recommended improvements to increase system performance, or recommended repairs to damaged or deteriorated components.
- e. Copies of completed work orders.

Examine the daily logs to identify possible deficiencies (i.e., extreme power level shifts). Check the auxiliary generator fuel report to see that the quantity of fuel is correct and that the water content is in accordance with the standard operating procedures.

Verify that the contractor's reports are furnished on forms approved by the KO. If any reports are incomplete and the contractor does not justify omissions (such as supporting schedules for infrequently required operations), consider the documentation unsatisfactory.

2. The power outage records are complete.

Review the contractor's electrical system outage records, compare the contractor's performance with historical data, and look for any adverse performance trends. Verify that the outage records include the following information:

- Date and time of outage
- Time outage was reported
- Who reported the outage
- Who took the report
- Portion of system affected
- Repair crew assigned and time
- Repair action taken
- Time service was restored
- Cause of outage
- Additional corrective action required or recommended.

3. An adequate spare parts inventory is being maintained in case of emergency repairs.

Verify that the contractor is maintaining an adequate inventory of electrical distribution spare parts (i.e., cable, poles, etc.) for emergency repairs. The number and types of spare parts should be determined locally as a percent of the equipment installed in the field.

4. If required, monthly readings for all electric customers are collected, recorded, and submitted.

Verify that the contractor collects, records, and submits monthly readings for all customers as required by contract. Use the listing of metered electric users and the random sampling procedures to select the electric meters to be checked. Collect the meter readings from the selected locations and compare them with those furnished by the contractor. The readings should agree, with allowance for usage between the two readings. Check contractor documentation to see that unusually high usages are identified and confirmed by the contractor as having a reasonable cause. Unjustifiably high customer or master meter readings must be satisfactorily explained and the condition resolved.

5. All auxiliary generators and auxiliary power operations are exercised and tested.

Verify that the contractor exercises and tests all auxiliary generators and auxiliary power operations. During nonemergency exercising, see that the contractor runs each generator up to operating temperature (i.e., approximately 15 minutes) before loading. In addition, when run testing is complete, see that the contractor allows for a running cooldown period (i.e., approximately 15 minutes) after loading has been removed before shutting the generator down. Plan unscheduled inspections to verify contractor performance.

6. The automatic start and load assumption cycles for all auxiliary generators are exercised.

Verify that the contractor exercises the automatic start and load assumption cycles for all auxiliary generators. Verify that the Automatic Transfer Switch (ATS) automatically turns on the generator and transfers the facility from utility line power to auxiliary power when a utility line power outage is simulated during the testing.

7. "As-built" drawings are updated with changes and corrections.

Verify that the contractor is maintaining current "as-built" drawings of electrical distribution system facilities and equipment. Check to see that the drawings are updated annually with all changes and corrections. The draftperson's initials and the date should accompany each change.

8. An adequate library of equipment manufacturers' manuals is being maintained.

Verify that the contractor is maintaining an adequate library of manufacturer's manuals for equipment and facilities. Manuals should be obtained for newly installed equipment and obsolete manuals discarded.

Recommended Surveillance Approach

- Evaluate performance indicators #1, #2, and #3 monthly using the 100 percent inspection method.
- Evaluate performance indicator #4 monthly using random sampling (normal surveillance, 10 percent AQL).
- Evaluate performance indicator #5 periodically using the unscheduled inspection method.
- Evaluate performance indicator #6 quarterly using the 100 percent inspection method.
- Evaluate performance indicators #7 and #8 annually using the 100 percent inspection method.

Electrical Distribution System Maintenance

Performance Indicators and Detailed Inspection Tasks

The following numeric items are performed by the contractor. The related detailed inspection tasks are used by the QAE to verify the contractor's performance.

1. The PMI report is complete, legible, and timely.

Verify that the contractor's PMI report is complete, timely, and covers all electrical distribution system components. Document any discrepancies between the QAE inspection and the contractor's PMI report.

2. The PM report is complete, legible, and timely.

Verify that the contractor's PM report is complete, timely, and covers all electrical distribution system components. Document any discrepancies between the QAE inspection and the contractor's PM report.

Evaluate the site's PM program using the following indicators:

- a. Check to see that the contractor revises the PM program annually to reflect system changes. For each major category of equipment, the PM program and report should include:
 - (1) Systematic inspection and documentation of findings.
 - (2) Description of specific maintenance programs based on the inspection findings.
 - (3) Job documents defining the necessary work, priorities, and related information.
 - (4) Date when maintenance was performed and when it should be performed next.
 - (5) Special procedures or requirements to be followed.
- b. Compare the frequency and cost of required repairs with historical records of the electrical distribution system to further evaluate the contractor's effectiveness. If the interval between equipment repairs is decreasing significantly, notify the KO. If historical data is not available, start a repair file on each major component for future reference.
- c. Accurate and complete property records are essential for proper evaluation of PM programs. They should include, as a minimum, the following:
 - (1) Description of item and location
 - (2) Manufacturer, type, serial number, etc
 - (3) Ratings
 - (4) Date installed

(5) Tests performed

(6) Description and date of any subsequent tests, maintenance, repairs, etc.

3. On-site inspections of the electrical distribution system verify satisfactory contractor PM.

Conduct on-site inspections of the electrical distribution system to verify that PM is adequate. Check to see that the contractor establishes a specific method of recording data on forms that index inspection sheets to map locations and a maintenance log to document inspection maintenance and repairs. Schedule the inspection so that the contractor may be present. Document any discrepancies between the QAE inspection and the contractor's PMI report.

Evaluate the site's operations and conditions using the following indicators:

- a. Poles. Poles should be plumb or straight. The tops of the poles should be inspected for areas that have cracked or split from lightning or improper guying. Pole butts should be inspected for split, rotten, or decaying wood. It may sometimes be desirable to inspect at or below the ground line for rot.
- b. Right-of-Way. There should be sufficient horizontal and vertical clearance from the primary and secondary conductors. Trees or shrubs may need to be cleared or trimmed.
- c. Anchor and Guys. Guys should be tight, and the pole attached to the guys should either be straight or lean slightly into the direction of the guy and anchor. Guy strands should not be rusted, and strands should not be broken. Anchor rods should be 6-in. to 1-ft above the ground. Anchor rods below the ground will eventually cause the guy strand to rust. Anchor rods too far out of the ground will decrease the strength of the guy and anchor. Guy guards should be installed where there is potential pedestrian traffic. In a grounded neutral system, the guy should be bonded to the system neutral. A delta system should have insulators on all guys.
- d. Pole Top Assemblies. If the pole top assembly contains a crossarm, the crossarm should be horizontal and at a right angle to the pole. Braces supporting the crossarm should be tight and unbroken, and insulator pins on angle structures should be straight. Insulators should not be chipped or broken. Hardware should be kept tight with lock nuts. If the nuts are loose, the hardware will cause radio noise.
- e. Grounds. Grounds should be stapled tightly to the pole and should not be loose, broken, or have broken strands.
- f. Primary Conductor. Conductors should have adequate clearance to ground and should have an even sag for each of the conductors. (Sags that differ greatly may indicate that splices were installed and that the wires are tensioned too tightly.) There should be no broken wire strands on the conductor. The conductor should be tightly tied or bolted to the insulators.
- g. Secondary Conductor and Services. Span lengths of the secondary conductor should not be excessive. Insulation should adhere tightly to the conductor.
- h. Reclosers, Sectionalizers, Transformers, Regulators, and Capacitors. All of these items make up a large part of the distribution system investment. It is recommended that cards

or similar records be kept that completely describe these units. Data should include original cost, location, ratings, tests, and maintenance performed. Jumpers that connect the equipment should have enough clearance from the pole (a minimum of 9-in. for 7.2 KV systems). Abnormally high operating temperatures should not be detected. QA instrumentation (Johnson 1993) is recommended to check for high operating temperatures.

- i. **Underground Equipment.** Transformers and pad-mounted equipment should be level, and trenches should be filled. All equipment should be padlocked to prevent unauthorized access to enclosures. Underground risers should have a cable guard which should be supported, and guy wires should be clear of the energized conductor. Enclosures should be free from rust and corrosion damage. Warning systems should be installed along the cable route and on pad-mounted equipment. Abnormally high operating temperatures should not be detected. QA instrumentation (Johnson 1993) is recommended to check for high operating temperatures.
- j. **Auxiliary Generators.** Verify the following maintenance items before the monthly exercising of each generator randomly chosen for inspection:
 - (1) Verify that lubricating oil is at a proper level and condition. Loss of oil may indicate a leak. An increase in the oil level may indicate condensation or leakage of coolant into the oil sump, or dilution with fuel.
 - (2) Examine the cooling water level. For engines that circulate water through a heat exchanger or radiator, a change in the level may indicate a leakage in the system. For engines with a once-through cooling system, check the availability of water.
 - (3) Check the radiator or heat exchanger for fouling. Verify the operation of any louvers or fans in the cooling air systems or pumps used in the secondary cooling water systems.
 - (4) Visually check the condition of cooling water hoses and accessory belt drives.
 - (5) Check all freeze protection mechanisms in all water systems.

4. **The contracted SO and IJO work was done in a timely, effective, and professional manner.**

Verify that contracted SO and IJO work was done in a timely, effective, and professional manner. The overall quality and appearance of the repair, including materials, must be comparable to the facility's original construction quality and appearance. Document any discrepancies between the QAE inspection and the contractor's report of work completed.

Visit the site of the selected repair to verify that the work is being performed with minimal service interruptions. After completion of the repair work, check to see that the construction area is clear of debris and that excavated areas are graded to match the surrounding area. Plan an unscheduled visit to the site to see that excavated areas that have settled are reshaped.

Recommended Surveillance Approach

- Evaluate performance indicators #1 and #2 monthly using the 100 percent inspection method.
- Evaluate performance indicator #3 monthly using random sampling (normal surveillance, 10 percent AQL).

- For performance indicator #4, evaluate SOs monthly using random sampling (normal surveillance, 4 percent AQL) and questionnaire feedback, and evaluate IJOs monthly using the 100 percent inspection method.

ACRONYMS

AQL	Acceptable Quality Level
ATS	Automatic Transfer Switch
COR	Contracting Officer's Representative
DEH	Director of Engineering and Housing
IJO	individual job order
KO	Contracting Officer
MIL-STD	Military Standard
O&M	Operations and Maintenance
PM	preventive maintenance
PMI	preventive maintenance inspection
QA	quality assurance
QAE	Quality Assurance Evaluator
QASP	QA Surveillance Plan
SO	service order

REFERENCES

- Johnson, James, Special Report FF-93/DRAFT, *Catalog of Industrial Instrumentation for Army Real Property Quality Assurance Applications* (U.S. Army Construction Engineering Research Laboratory, 1993).
- Military Standard 105E, *Sampling Procedures and Tables for Inspection by Attributes* (Department of Defense, 10 May 1989).

APPENDIX A: Inspection Sampling Tables

Table A1

Sample Sizes and Reject Levels (4% AQL)
(As developed from Tables I & II in MIL STD 105E)

Population Size	Normal Surveillance			Increased (Tightened) Surveillance			Reduced Surveillance		
	Class II Sample Size	Reject Level		Class III Sample Size	Reject Level		Class I Sample Size	Reject Level	
08 to 50	*	25%	1	*	40%	1	*	-	-
51 to 90	E	13	2	F	20	2	*	3%	1
91 to 150	F	20	3	G	32	3	*	3%	1
151 to 280	G	32	4	H	50	4	E	5	2
281 to 500	H	50	6	J	80	6	F	8	3
501 to 1200	J	80	8	K	125	9	G	13	4
1201 to 3200	K	125	11	L	200	13	H	20	5

The Reject Level is the number of failed inspections requiring rejection of the Lot (population).
An asterisk (*) indicates that the sample level is outside the range of a 4% AQL for the selected class.

Table A2

Sample Sizes and Reject Levels (10% AQL)
(As developed from Tables I & II in MIL STD 105E)

Population Size	Normal Surveillance			Increased (Tightened) Surveillance			Reduced Surveillance		
	Class II Sample Size	Reject Level		Class III Sample Size	Reject Level		Class I Sample Size	Reject Level	
06 to 15	*	33%	1	*	50%	1	*	-	-
16 to 25	C	5	2	D	8	2	*	8%	1
26 to 50	D	8	3	E	13	3	C	2	2
51 to 90	E	13	4	F	20	4	C	2	2
91 to 150	F	20	6	G	32	6	D	3	3
151 to 280	G	32	8	H	50	9	E	5	4
281 to 500	H	50	11	J	80	13	F	8	5
501 to 1200	J	80	15	K	125	19	G	13	6
1201 to 3200	K	125	22	L	200	19	H	20	8

The Reject Level is the number of failed inspections that require rejection of the Lot (population).
An asterisk (*) indicates that the sample level is outside the range of a 10% AQL for the selected class.

Table A3

Random Numbers

2	6	1	6	9	3	5	5	1	1	3	1	2	5	5	1	7	8	7	5	6	6	8	4	4	9	4	6	2	8	9	3	5	
1	8	1	4	5	9	2	7	2	2	5	4	9	1	9	2	9	4	9	2	9	3	6	3	5	1	4	3	1	1	1	1	6	1
4	2	3	6	8	4	6	3	2	6	6	8	8	5	4	9	1	1	3	2	8	6	1	9	8	7	1	2	4	3	4	1	3	
2	7	2	4	8	8	8	3	5	3	3	2	6	3	9	3	2	7	7	1	8	3	5	9	6	8	1	5	9	3	2	4	6	
8	4	1	3	7	4	4	6	1	6	9	6	3	7	5	6	2	1	4	3	2	8	5	7	8	2	4	7	7	7	4	2	6	
2	6	4	8	1	5	4	9	7	1	7	3	3	7	2	1	7	4	4	7	7	8	2	7	5	7	6	5	6	6	2	5	8	
1	9	8	6	9	6	8	3	7	5	4	1	3	6	1	1	3	3	2	8	7	5	4	1	9	1	4	9	7	1	8	4	8	
1	4	3	7	5	6	5	5	9	9	4	6	4	6	2	3	4	5	8	9	9	9	8	3	2	3	2	7	7	5	9	9	8	
8	3	6	3	8	6	3	8	9	6	1	9	3	9	8	3	9	8	5	6	4	9	5	8	7	4	3	7	8	2	3	8	4	
1	5	2	5	8	3	7	5	2	3	7	9	4	4	4	4	8	3	1	2	6	7	2	9	9	7	8	4	2	3	4	1	4	
1	5	7	2	9	4	2	5	6	4	8	6	1	3	5	4	5	1	9	2	2	1	5	9	7	5	7	6	7	5	5	6	3	
6	9	2	7	1	9	7	7	5	4	3	6	6	3	6	3	4	4	6	6	8	3	8	1	4	7	9	1	4	7	2	7	7	
2	5	5	8	6	6	7	8	5	8	2	6	2	4	3	2	7	6	6	1	7	4	3	2	8	4	8	9	3	1	7	7	7	
6	1	1	9	1	9	2	9	9	9	1	2	8	6	4	7	3	7	5	4	7	1	8	1	3	4	2	1	5	9	2	5	7	
9	9	5	1	1	4	8	9	9	8	2	6	9	3	3	2	5	9	5	7	9	6	2	8	3	1	1	9	3	3	1	6	2	
9	6	1	8	8	7	7	8	3	2	2	5	2	6	3	6	6	4	5	2	2	8	1	3	3	2	3	3	6	9	3	9	4	
2	2	8	7	7	3	8	1	7	8	2	8	8	3	3	9	8	5	7	1	7	3	6	2	7	6	5	9	6	8	2	7	7	
3	9	6	7	1	1	4	7	3	6	9	2	7	4	8	8	3	2	5	8	4	2	2	9	1	4	8	4	6	5	3	6	4	
3	6	4	2	9	6	4	4	6	9	7	8	8	4	7	3	5	5	1	7	9	5	9	8	4	8	7	1	1	3	2	5	8	
7	6	5	6	3	1	9	7	8	9	8	1	7	6	8	8	9	3	5	8	3	1	9	4	6	7	4	2	7	4	7	9	8	
5	4	7	2	8	9	2	7	2	1	3	5	6	1	9	6	8	3	7	8	9	9	6	5	9	6	4	8	7	5	9	5	5	
2	2	6	5	1	1	3	3	7	6	1	7	4	4	4	9	5	2	5	9	1	7	2	5	4	9	9	4	9	9	8	8	2	
4	6	6	8	6	4	6	1	5	4	6	3	9	6	8	4	5	6	2	4	2	4	1	8	3	8	4	3	5	9	5	9	6	
4	5	7	4	1	8	8	2	3	5	6	3	5	3	2	1	8	2	9	2	5	6	5	1	9	9	4	8	4	4	4	4	5	
9	9	9	1	1	9	5	8	9	9	8	9	8	3	4	7	9	1	2	5	7	5	3	6	5	4	2	3	1	8	8	3	5	
2	2	7	4	6	8	2	2	5	9	4	4	2	3	7	9	5	7	7	8	8	1	3	1	4	3	1	1	6	1	2	5	8	
8	5	7	3	9	8	7	9	2	2	1	9	7	9	8	6	1	1	9	8	5	3	6	4	3	3	9	6	3	8	1	5	1	
7	9	4	2	3	8	6	1	7	6	7	5	3	4	3	5	2	1	4	7	6	9	1	8	9	2	4	4	3	7	4	8	1	
1	3	7	8	6	8	7	8	9	9	3	3	1	6	3	3	8	4	3	3	4	8	1	8	6	3	4	9	9	8	4	5	4	
5	4	7	4	9	3	7	3	1	9	2	3	8	7	3	8	9	2	5	1	5	9	4	2	4	9	1	9	9	8	1	7	9	
7	6	7	6	2	7	3	2	5	7	9	3	4	4	4	2	6	1	5	2	4	5	1	7	9	9	2	8	6	6	8	8	5	
8	4	6	5	9	2	1	3	5	5	1	7	8	6	1	7	9	8	3	6	6	9	1	7	9	2	2	9	6	7	1	5	3	
2	3	6	2	7	9	5	6	2	9	7	2	4	2	7	4	7	7	5	4	6	9	7	5	1	9	9	1	2	9	6	7	5	
6	2	2	4	5	8	2	9	4	9	5	6	2	6	3	6	2	6	6	2	1	3	9	6	8	4	6	1	4	2	5	7	4	
6	3	5	4	9	1	1	2	1	2	7	1	1	5	9	1	1	7	2	3	2	1	1	7	9	5	5	3	8	7	8	9	1	
2	4	7	6	7	9	3	2	2	2	2	8	1	3	4	2	9	8	7	6	9	5	7	8	6	5	8	5	3	6	8	6	2	
6	9	1	7	1	4	6	4	7	6	5	8	5	4	9	4	8	8	4	5	5	8	1	7	9	5	9	3	2	1	3	7	6	
4	8	4	1	9	8	6	4	7	4	4	1	5	9	2	4	3	3	6	7	4	8	9	2	1	5	4	3	7	2	5	1	2	
2	1	6	8	6	8	3	6	1	4	5	7	9	6	8	7	2	3	8	6	2	9	9	1	3	4	7	5	4	4	3	9	8	
9	8	5	4	5	6	1	4	3	6	2	9	6	1	9	8	1	8	8	9	9	9	5	1	7	4	9	2	1	9	1	6	6	
5	3	2	7	5	6	1	3	3	3	5	4	1	2	4	6	2	3	3	2	5	7	9	1	8	3	8	4	6	1	1	1	6	
2	2	7	7	2	5	7	2	6	1	1	2	1	6	1	8	6	6	8	1	2	1	4	8	5	2	8	4	1	1	7	3	9	
2	8	9	4	9	9	6	8	4	3	2	3	9	9	4	7	3	2	4	1	9	6	5	4	1	8	5	3	7	7	3	6	9	
2	3	4	9	7	5	3	2	4	6	4	4	6	8	6	3	1	1	8	9	6	4	7	7	6	3	1	5	7	8	9	7	7	
6	7	9	5	5	8	5	4	4	5	6	1	4	9	4	5	3	1	7	3	2	1	8	6	2	2	4	7	8	1	4	5	9	
5	3	7	8	6	6	4	1	1	4	4	2	5	1	1	4	8	9	4	2	8	9	9	7	2	4	7	8	4	1	8	1	1	
7	2	3	2	1	7	2	8	6	4	6	9	7	3	9	3	3	4	4	7	1	4	4	8	8	6	7	4	1	9	9	5	1	
8	4	3	4	9	2	7	2	6	3	7	9	8	3	1	9	9	5	8	7	1	2	9	9	6	6	8	8	8	7	8	4	8	

APPENDIX B: QAE Inspection Worksheets

Electrical Supply Station Operations Worksheet

Page 1 of 2

Performance Indicator #1: The logs and checklists are complete, legible, and timely.

a. The contractor's logs and checklists are complete, legible, and timely.

S U N

b. Documentation includes:

(1) Dates and the initials of the person(s) who did or accepted the work.

(2) Description of normal operations.

(3) Reports of corrective actions taken.

(4) Recommended improvements and repairs.

S U N

c. Reports are furnished on KO approved forms and all omissions have been adequately justified.

S U N

Remarks:

Performance Indicator #2: The power outage records are complete.

a. The contractor's records are complete.

S U N

b. When compared to historical data, no adverse trends exist.

S U N

Remarks:

*S = Satisfactory, U = Unsatisfactory, N = Not applicable. Circle one rating for each item.

Performance Indicator #3: "As-built" drawings are updated with changes and corrections.

- a. The draftperson's initials accompany each change.

S U N

- b. The date of change accompanies each correction.

S U N

Remarks:

Performance Indicator #4: An adequate library of equipment manufacturer's manuals is being maintained.

- a. Manuals for new equipment have been obtained.

S U N

- b. Obsolete manuals have been properly discarded.

S U N

Remarks:

Quality Assurance Evaluator

Date

Performance Indicator #1: The PMI report is complete, legible, and timely.

- a. All items are listed, dated, and initialed as completed.

S U N

- b. The report is timely.

S U N

Remarks:

Performance Indicator #2: The PM report is complete, legible, and timely.

- a. All items are listed.

S U N

- b. The report is timely.

S U N

- c. The PM program is adequate.

S U N

- d. The contractor's repair frequency is acceptable.

S U N

- e. Accurate property records are maintained.

S U N

Remarks:

Performance Indicator #3: On-site inspections of the electrical supply stations verify satisfactory PM performance.

- a. The contractor establishes a specific method of recording data.
- b. The following areas are satisfactory:
 - (1) General areas
 - (2) Painting and galvanizing
 - (3) Fencing
 - (4) Surfacing
 - (5) Oil leaks
 - (6) Grounding system
 - (7) Porcelain
 - (8) Buses and conductors
 - (9) Oil levels
 - (10) Lighting
 - (11) Switchgear and switchboards
 - (12) Circuit breaker counters
 - (13) Batteries.

Using the population size _____, and referring to normal surveillance in Tables A1 and A2 gives _____ number of samples and _____ number of allowable rejects.

LOCATION

_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N

Remarks:

Performance Indicator #4: The contracted SO and IJO work was done in a timely, effective, and professional manner.

a. The overall quality and appearance of the repair is comparable to that of the facility's original construction.

b. Work is performed with minimal interruptions.

c. The construction area is clear of debris.

d. Excavated areas are graded to match the surrounding area.

Using the population size _____, and referring to normal surveillance in Tables A1 and A2 gives _____ number of samples and _____ number of allowable rejects.

LOCATION	SO/IJO	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N
_____	_____	S	U	N

Quality Assurance Evaluator

Date

Performance Indicator #1: The inspection and operating records for distribution equipment are complete, legible, and timely.

a. The checklist is timely.

S U N

b. The operations records contain information about:

(1) Dates and the initials of the person(s) who did or accepted the work.

(2) The description of normal inspection, operation, and maintenance.

(3) Reports of corrective actions taken.

(4) Recommended improvements or repairs.

(5) Copies of completed work orders.

S U N

c. Daily logs do not show deficiencies such as extreme power level shifts or questionable data.

S U N

d. The quantity of auxiliary generator fuel is correct, and the water content is acceptable.

S U N

e. The contractor's reports are furnished on forms approved by the KO.

S U N

Remarks:

Performance Indicator #2: The power outage records are complete.

a. The records are complete.

S U N

b. When compared to historical data, no adverse trends exist.

S U N

Remarks:

Performance Indicator #3: An adequate spare parts inventory is being maintained in case of emergency repairs.

S U N

Remarks:

Performance Indicator #5: The contractor exercised and tested all auxiliary generators and auxiliary power operations.

LOCATION	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N

Remarks:

Performance Indicator #6: The contractor exercised the automatic start and load assumption cycles for all auxiliary generators.

LOCATION	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N

Remarks:

Performance Indicator #7: "As-built" drawings are updated with changes and corrections.

a. The draftperson's initials accompany each change.

S U N

b. The date of change accompanies each correction.

S U N

Remarks:

Performance Indicator #8: An adequate library of equipment manufacturer's manuals is being maintained.

a. Manuals for new equipment have been obtained.

S U N

b. Obsolete manuals have been properly discarded.

S U N

Remarks:

Quality Assurance Evaluator

Date

Performance Indicator #1: The PMI report is complete, legible, and timely.

- a. The report is complete and legible.

S U N

- b. The report is timely.

S U N

Remarks:

Performance Indicator #2: The PM report is complete, legible, and timely.

- a. All items are listed.

S U N

- b. The report is timely.

S U N

- c. The contractor's PM program is adequate.

S U N

- d. The contractor's repair frequency is acceptable.

S U N

- e. Accurate property records are maintained.

S U N

Remarks:

Performance Indicator #3: On-site inspections of the electrical distribution system verify satisfactory contractor PM.

- a. The contractor establishes a specific method of recording data.
- b. The following areas are satisfactory:
 - (1) Poles
 - (2) Right-of-way
 - (3) Anchor and guys
 - (4) Pole top assemblies
 - (5) Grounds
 - (6) Primary conductor
 - (7) Secondary conductor and services
 - (8) Reclosers, sectionalizers, transformers, regulators, and capacitors
 - (9) Underground equipment
 - (10) Auxiliary generators.

Using the population size _____, and referring to normal surveillance in Tables A1 and A2 gives _____ number of samples and _____ number of allowable rejects.

LOCATION

_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N
_____	S	U	N

Remarks:

This survey should be completed using information collected from the person who has had the most contact with maintenance personnel. Please circle the letter of the answer selected or write in an appropriate answer where there are blanks.

1. Response (in days) to repair requested work:

- a) Excellent response (normal conditions - 7 days)
(emergency conditions - 1 day)
- b) Adequate response (within 2 weeks)
- c) Too long (Approximately how long? ___ days)

2. Quality of work: (Are you satisfied that quality work was performed?)

Yes ___ No ___ Defect was not fixed ___

Explain: _____

3. Cleanup of area after repair: (Was area left as clean as it was before work personnel arrived?)

Yes ___ No ___

Comments: _____

4. Efforts of work personnel: (Are you satisfied that the work was performed in a professional, effective manner?)

Comments: _____

5. Attitude of work personnel: (Were they helpful, friendly, courteous, cheerful?)

Comments: _____

6. Do you think this type of repair could be accomplished as "self help" if material and instructions were supplied?

Yes ___ No ___ Maybe ___

7. **Remarks:** _____

Thank you for your cooperation.

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