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QA Inspections Via Condition Monitoring

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

## Guide #5: Heating 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 heating system operations and maintenance.

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## **FOREWORD**

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# **GUIDELINES FOR QUALITY ASSURANCE INSPECTION OF COMMERCIAL ACTIVITIES CONTRACTS FOR REAL PROPERTY MAINTENANCE ACTIVITIES GUIDE #5: HEATING 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 heating 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 (SR FF-94/04)
- #5: **Heating Systems**
- #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)

- #10: Refuse and Recyclable Handling (SR FF-94/10)
- #11: Pest Control Services (SR FF-94/11)
- #12: Custodial Services (SR FF-94/12).

The QAE is expected to evaluate a contractor's performance by applying appropriate visual and instrumentation procedures along with necessary technical and interpretive skills. This guide covers QAE inspection of wastewater systems, and is divided into sections that take the inspector through a step-by-step process of recommended performance indicators, inspection tasks, and surveillance methods.

Heating systems are divided into two subsystems in this guide:

1. Heating Systems Operations
2. Heating Systems Maintenance.

General QA information, including detailed explanations of the available surveillance methods, is given in Chapter 2.

Chapter 3 provides performance indicators, inspection tasks, and recommended surveillance approaches for each subsystem.

Appendix A contains sampling inspection tables. Appendix B contains QAE worksheets for each subsystem and a service order questionnaire; they may be reproduced for field use.

## **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 heating systems.

### **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. Typically, 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 HEATING SYSTEMS QA INSPECTIONS**

#### **Heating Systems 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. All required operations documentation is complete, legible, and timely.

Verify that all required operations documentation is complete, legible, and timely.

- a. Examine the daily log to identify possible deficiencies in operation such as drops in output pressure or questionable data.
  - b. Check the fuel storage and accountability report to see that it includes reports of fuel consumed, quantity remaining, and water content. Note any deviations from the norm so that the KO may review them and ask the contractor for explanation or justification.
  - c. Check the boiler water treatment log for completeness and, if necessary, check the report against the standards outlined in Army Technical Manual 5-650, *Central Boiler Systems* (August 1962).
2. An unscheduled walk-through inspection shows no out-of-range boiler or steam distribution pressures or temperatures, and no excess leakage or unsafe conditions.

Read calibrated permanent gauges and apply handheld QA inspection instrumentation to determine pressure and temperature readings at random and key distribution points.

3. Operations records show that:

- a. The output steam pressures of the boilers met but did not exceed the acceptable pressures stated in the installation's standard operating procedures.

Examine the strip record of measured operating pressures to see that the boiler pressures met but did not exceed the acceptable pressures stated in the installation's standard operating procedures. If any of the pressure readings are unacceptable, note the date, time, pressure, and the date and time that proper pressure was restored.

- b. All pressure losses lasting longer than 30 minutes are reported to the KO.

Check the contractor's records to see that pressure losses lasting more than 30 minutes are reported to the KO within 30 minutes of their occurrence.

- c. All reports of heat problems are responded to in a timely manner, and any problems corrected within 2 hours.

Check contractor's logs to see that the contractor responded in a timely manner to reports of loss of heat, corrected any problems, and restored pressure within 2 hours.

- d. When requested by the KO, deactivated boilers are brought on-line within 8 hours.

Check contractor's logs to see that, when requested by the KO, a deactivated boiler is brought on-line within 8 hours. If the boiler is activated because of an emergency, also check the contractor's report to determine compliance.

4. Supplementary services are provided (such as incinerator operation) during the period identified in the contract.

Verify at the site that contractor activities satisfy all services required in the contract.

5. "As-built" drawings are updated with changes and corrections made to the extent feasible.

Verify that the contractor is maintaining current "as-built" drawings of heating 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.

6. 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 should be discarded.

#### *Recommended Surveillance Approach*

- Evaluate performance indicators #1 and #2 monthly using the 100 percent inspection method.
- Evaluate performance indicator #3 weekly using the 100 percent inspection method.
- Evaluate performance indicator #4 periodically using the unscheduled inspection method.
- Evaluate performance indicators #5 and #6 annually using the 100 percent inspection method.

### **Heating Systems 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) reports are complete, legible, and timely.

Verify that the contractor's PMI reports for boilers, distribution systems, incinerators, and mechanical rooms are complete, legible, and timely. Document any discrepancies between the QAE inspection and the PMI report.

2. An adequate level of Preventive Maintenance (PM) is performed.

Verify that the contractor performed an adequate level of PM on boilers, distribution systems, incinerators, and mechanical rooms. Document any discrepancies between the QAE inspection and the contractor's PM report.

*For Heating Plants and Systems, check to see that:*

**a. Boilers are:**

- (1) Clean and free of hazardous conditions.**
- (2) Free of leaks. Water sides are free of scale and sludge, and gas sides are free of soot and carbon accumulations. QA instrumentation is recommended to search for boiler leaks (Johnson 1993).**
- (3) Not operating at excessive temperatures. QA instrumentation is recommended to check for high operating temperatures (Johnson 1993).**

**b. Electric motors and generators are:**

- (1) Securely fastened and aligned. QA instrumentation is recommended to check for shaft misalignment (Johnson 1993).**
- (2) Free of excessive vibration. QA instrumentation is recommended to check for excessive vibration (Johnson 1993).**
- (3) Properly lubricated. Bearings are cool and well-lubricated. QA instrumentation is recommended to check bearing condition (Johnson 1993).**
- (4) Free of dirt, restricted air circulation, or overload. QA instrumentation is recommended to check for overload (Johnson 1993).**

**c. Combustion:**

- (1) Air openings and grills are free of obstructions and allow adequate air flow to the heater combustion chamber.**
- (2) Chambers show no evidence of breakage or damage.**
- (3) Electronic safeguards are functioning properly.**
- (4) Heating system combustion efficiency is adequate. QA instrumentation is recommended to check heating system combustion efficiency (Johnson 1993).**

**d. Control devices:**

- (1) The float and lever system produces a force great enough to operate regulating valves.**
- (2) Leaks and accumulation of scale are not present in float controls. QA instrumentation is recommended to detect leaks (Johnson 1993).**
- (3) Pressure controls and reducing valves show no signs of corrosion, wear, or pitting.**
- (4) There is no sign of leakage in gas thermometer systems. QA instrumentation is recommended to detect leaks (Johnson 1993).**

**e. Steam and hot water distribution system:**

- (1) Condensate or vacuum pump casings and lines show no signs of leaking. QA instrumentation is recommended to detect leaks (Johnson 1993).**
- (2) Proper temperature is maintained in converters on heat exchangers. There is no coil leakage. QA instrumentation is recommended to detect leaks and improper temperatures (Johnson 1993).**
- (3) Steam or water piping shows no evidence of leakage or loose insulation. QA instrumentation is recommended to detect leaks (Johnson 1993).**
- (4) Valves are opening and closing properly.**

**f. There are no steam or water leaks. QA instrumentation is recommended to detect leaks (Johnson 1993). Test the following for leaks:**

- (1) Storage tanks.**
- (2) Condensate tanks.**
- (3) Any other system components.**

**g. The following areas are clean and free of hazardous conditions:**

- (1) Furnace rooms are clean and free of hazardous conditions.**
- (2) The area around the heaters is free of fire hazards such as oil spills or other combustible materials.**
- (3) There are no accumulations of soot or flyash in smoke breeching and flues that exceed a thickness of 1/2-in. (1.27 cm) at a point 1-ft (0.305 m) below the building roof.**
- (4) Openings around vents in oil storage tanks are clear.**
- (5) Condensate tanks are clean with no accumulated debris.**

**h. The following are properly adjusted and operating properly:**

- (1) Burners do not flash back, which would indicate a need for change or adjustment.**
- (2) Accessories, fittings, and controls operate properly.**
- (3) All parts move freely and function properly.**
- (4) Pressure controls operate properly.**
- (5) Belts are properly adjusted and are not frayed, worn, or cracked.**
- (6) Readings on gauges compare appropriately to those on previous records.**

**i. Lubrication and corrosion:**

- (1) Equipment is lubricated properly and regularly to prevent metal-to-metal contact, eliminate wear, and reduce corrosion.**
- (2) Operation is smooth (check by feel and sound). QA instrumentation is recommended to check for excessive vibration (Johnson 1993).**
- (3) Oil pressures and levels are at the required values.**
- (4) There are no signs of rusting or corrosion of any part of the heating system, and all pertinent surfaces have adequate coatings. QA instrumentation is recommended to check for corrosion/coating condition (Johnson 1993).**

**j. All insulation is dry.**

**k. No parts are broken, warped, damaged, distorted, or burned.**

**l. All nuts, bolts, and holding parts are tight.**

**m. All hoses and flexible connections are in good condition.**

**For Gas-Fired, Forced-Warm-Air Furnaces, check to see that:**

**a. The following components are properly adjusted:**

- (1) The air/fuel mixture. Check that the mixture is optimum for furnace efficiency. QA instrumentation is recommended to check for furnace combustion efficiency (Johnson 1993).**
- (2) The pilot flame or thermocouple.**
- (3) The air shutter.**
- (4) The regulator. Check that the regulator provides the proper gas flow.**
- (5) The thermostat. Check that the thermostat maintains the appointed temperature.**

**b. The following components are clean:**

- (1) The air shutter.**
- (2) The mixer and burner ports.**
- (3) The air filter. Check that the filter is not overly dirty.**

**c. Test for fluid leaks. QA instrumentation is recommended to detect leaks (Johnson 1993). The following leak conditions do not exist:**

- (1) Carbon monoxide leaks.**

- (2) Combustible gas leaks.
  - d. The following are not broken, damaged, or deteriorated:
    - (1) Recirculating fan/motor belts.
    - (2) Registers, louvers, etc.
  - e. The motor works properly and exhibits no excessive vibration. QA instrumentation is recommended to check for excessive vibration (Johnson 1993).
  - f. There are no signs of rusting or corrosion of any part of the furnace system, and all pertinent surfaces have adequate coatings. QA instrumentation is recommended to check for corrosion/coating condition (Johnson 1993).
3. The contracted Service Order (SO) and Individual Job Order (IJO) work is done in a timely, effective, and professional manner.

Verify that the contracted SO and IJO work is 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 indicator #1 monthly using the 100 percent inspection method.
- Evaluate performance indicator #2 monthly using random sampling (normal surveillance, 10 percent AQL).
- For performance indicator #3, 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             |
| 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

- Army Technical Manual 5-650, *Central Boiler Systems* (Headquarters, Department of the Army, August 1962).
- 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 | 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**

**Heating Systems Operations Worksheet**

**Page 1 of 4**

**Performance Indicator #1:** All required operations documentation is complete, legible, and timely.

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

S      U      N

- b. The documentation is timely.

S      U      N

- c. The documentation indicates no possible deficiencies such as drops in output pressures or questionable data.

S      U      N

- d. The fuel storage and accountability report includes:

- (1) Fuel consumed
- (2) Quantity remaining
- (3) Water content.

S      U      N

- e. The boiler water treatment log is complete and conforms to standards.

S      U      N

**Remarks:**

**Performance Indicator #2:** Walk-through inspections are performed unannounced as follows:

- a. Readings from a handheld infrared temperature probe randomly and specifically applied are in a normal range for the operating system.

S      U      N

**Remarks:**

---

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

b. Gauges are unobstructed, not fluctuating or reading improperly, and dated/signed calibrations are attached or in a designated location.

S U N

Remarks:

c. All inspected gauges on the operating system are in normal pressure, temperature, and liquid-level ranges for the systems being inspected.

S U N

Remarks:

**Performance Indicator #3:** Operations records show that:

a. The output steam pressures of the boilers met but did not exceed the acceptable pressures stated in the installation's standard operating procedures.

S U N

Remarks:

b. All pressure losses lasting longer than 30 minutes are reported to the KO.

S U N

Remarks:

c. All reports of heat problems are responded to in a timely manner and any problems corrected within 2 hours.

S      U      N

Remarks:

d. When requested by the KO, deactivated boilers are brought on-line within 8 hours.

S      U      N

Remarks:

**Performance Indicator #4:** Supplementary services are provided (such as incinerator operation) during the period identified in the contract.

S      U      N

Remarks:

**Performance Indicator #5:** "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 #6:** An adequate library of equipment manufacturers' 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 reports are complete, legible, and timely.

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

S U N

b. The reports are timely.

S U N

Remarks:

**Performance Indicator #2:** An adequate level of PM is performed.

a. PM for the heating plants and systems is satisfactory.

b. PM for gas-fired, forced-warm-air furnaces is satisfactory.

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 |
| _____ | 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 |

## Heating Systems Maintenance Worksheet

Page 2 of 3

|  |   |   |   |
|--|---|---|---|
|  | S | U | N |
|  | S | U | N |
|  | S | U | N |

Remarks:

**Performance Indicator #3:** 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 |

Remarks:

\_\_\_\_\_  
Quality Assurance Evaluator

\_\_\_\_\_  
Date

## Service Order Questionnaire

Page 1 of 2

This survey should be completed with information from the person having the most contact with maintenance personnel. Please circle the letter of the answer selected or answer in the blanks, as appropriate.

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: (Is 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: (Are 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.**

\_\_\_\_\_  
**Quality Assurance Evaluator**

\_\_\_\_\_  
**Date Questionnaire Completed**

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ATTN: DEH  
ATTN: APEN-A  
HQ USEUCOM 09128  
ATTN: ECJ4-LIE

AMMRC 02172  
ATTN: DRXMR-AF  
ATTN: DRXMR-WE

CEWES 39180  
ATTN: Library

CECRL 03755  
ATTN: Library

USA AMCOM  
ATTN: Facilities Engr 21719  
ATTN: AMSMC-IR 61299  
ATTN: Facilities Engr (3) 85613

USAARMC 40121  
ATTN: ATZIC-EHA

Military Traffic Mgmt Command  
ATTN: MTEA-GB-EHP 07002  
ATTN: MT-LOF 20315  
ATTN: MTE-SU-FE 28461  
ATTN: MTW-IE 94626

Military Dist of WASH  
Fort McNair  
ATTN: ANEN 20319

Norton AFB 92409  
ATTN: Library

Engr Societies Library  
ATTN: Acquisitions 10017

Defense Nuclear Agency  
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197  
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