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**MODEL QUALITY PROGRAM MANUAL  
YEAR 2000 FIRMWARE MODIFICATION  
OF GAS MEASURING DEVICES**

**A Companion Document to  
Measurement Canada Publication QP-G-01**

**January 1999**

**Developed by the  
Canadian Gas Association / Measurement Canada  
Joint Working Group**

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## **PREFACE**

This document is the product of joint working group of Canadian Gas Association and Measurement Canada personnel.

Canadian Gas Association working group participants were:

Peter Wall, C.R. Wall & Co. Inc.  
Doug Kent, Union Gas Ltd.  
Barry Goulah, Enbridge Consumers Gas Ltd.  
Theodore Lakeberg, Mercury Instruments, Inc.

Measurement Canada working group participants were:

Bruce Lyng, Program Development, Gas  
Sam Stouros, Program Development, Accreditation  
Frank Palcat, Program Development, Gas

The document has been developed as a companion document to Measurement Canada publication G-QP-01 "Requirements and Procedures for the Authorization of Gas Measuring Device Firmware Modifications." The model Quality Program Manual addresses a firmware modification program for specific electronic gas volume conversion devices manufactured by Mercury Instruments, Inc.

This model Quality Program Manual consists of three major parts. The first part defines the Company's quality program policies and administrative procedures. The second part defines the technical procedures which are required to implement specific parts of the administrative procedures. The final part includes all appendices to the first two parts of the manual.

Organizations seeking authorization to perform firmware modification work under the Measurement Canada program are encouraged to make full use of the model quality documentation to expedite development and implementation of suitable quality program. Each interested organization is required to tailor the model documentation to their specific organizational structure and operations. Some of the areas to focus on in this adaptation include:

- (a) changing the company's name and generic position titles to those actually used by the applicant organization;
- (b) reviewing the assignment of responsibilities throughout the document to ensure compatibility with the applicant organization's operations;
- (c) modifying technical procedures for device inspection and standards calibration if the devices and standards that the organization will encounter differ from that specified in each procedure's scope;
- (d) adding technical procedures for any relevant activities such as firmware PROM programming or on-site device recalibration that the organization wishes to perform;
- (e) modifying terminology and adding definitions to facilitate quality program implementation within the organization;
- (f) adding other information to be captured during firmware modification, calibration, or inspection work and making associated changes to the procedures and forms.

Measurement Canada requires all changes to the model manual to be itemized, described, and documented with explanation as appropriate. The documented changes will be evaluated in conjunction with the organization's Quality Program Manual before authorization to proceed with program implementation is authorized.

**MODEL QUALITY PROGRAM MANUAL**

**YEAR 2000 FIRMWARE MODIFICATION**

**MERCURY INSTRUMENTS EC-AT CONVERSION DEVICES**

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## **PROGRAM POLICIES and PROCEDURES**

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1. Quality Policy
2. Organization
3. Process Control
4. Modification, Inspection, and Testing
5. Control of Inspection and Test Equipment
6. Corrective Action
7. Quality Records
8. Training

**1. QUALITY POLICY**

**1.1 QUALITY COMMITMENT**

The Company is committed to providing its customers with quality products, services, and accurate measurement. This commitment shall be demonstrated by the strict adherence of all involved personnel to the documented and controlled quality policies and procedures contained in this Quality Program Manual while performing the activities under the Program's scope.

Quality is the responsibility of all personnel involved in the performance of the Quality Program activities. All personnel are expected to identify and seek correction of any deficiencies that may inhibit the Company's quality commitment.

**1.2 QUALITY OBJECTIVE**

The objective of the Quality Program is to ensure that the maintenance work performed on the affected measuring devices and the associated conformance status of the measuring devices complies with Measurement Canada requirements. This Quality Program Manual describes the systems and controls utilized by the Company to ensure this compliance.

**1.3 QUALITY PROGRAM SCOPE**

This Quality Program applies to the firmware modification and associated inspection and testing of Mercury Instruments model EC-AT electronic-type gas volume conversion devices to permit Year 2000 compliance. The targeted conversion devices are programmed with firmware version 3.10 or 4.xx and following the upgrade will be programmed with firmware version 5.23. The conversion devices are identified in Measurement Canada Notice of Approval AG-0242.

**1.4 AUTHORIZATION**

The undersigned authorizes the use of the Quality Program Manual in the Company and assures that all activities shall be performed in strict accordance with the Manual's contents. Any changes to the Quality Program Manual's contents which are necessary to ensure continuing compliance with the quality objective shall be authorized by the undersigned and approved by Measurement Canada prior to implementation.

-----  
Measurement Manager  
199X-XX-XX

## **2. ORGANIZATION**

### **POLICY**

It is the policy of the Company to be organized in a manner such that the management, supervisory, and execution requirements of the Quality Program are effectively fulfilled.

### **ORGANIZATIONAL STRUCTURE**

#### **2.1 Purpose**

The purpose of this section is to define the team of personnel involved in the Quality Program.

#### **2.2 Scope**

This section applies to personnel with specified duties associated with the firmware modification of Mercury Instruments EC-AT conversion devices.

#### **2.3 Responsibilities**

2.3.1 The Company's management, supervisory, and execution responsibilities shall be divided among the Measurement Manager, Measurement Supervisor, and Measurement Technician positions (or equivalent titles as applicable to the Company).

##### **2.3.2 *Measurement Manager***

The Measurement Manager is responsible for:

- (a) the general management and maintenance of the Quality Program;
- (b) acting as liaison with Measurement Canada with respect to Quality Program activities, modifications, and reports; and
- (c) performing Quality Program implementation planning including identifying the target population of devices requiring maintenance, identifying and providing the required resources to implement the Program, training the Measurement Supervisor with respect to his duties, and assigning Program responsibilities to personnel.

##### **2.3.3 *Measurement Supervisor***

The Measurement Supervisor is responsible for:

- (a) selecting, providing for the training of, and evaluating and documenting training results for all Measurement Technicians responsible for doing Program work;
- (b) assigning work to Measurement Technicians and responsibility centres within the Company;
- (c) overseeing the day-to-day activities of the Measurement Technicians in performing the Program work, providing advice and guidance as needed, and reviewing reports of work completed for adequacy;

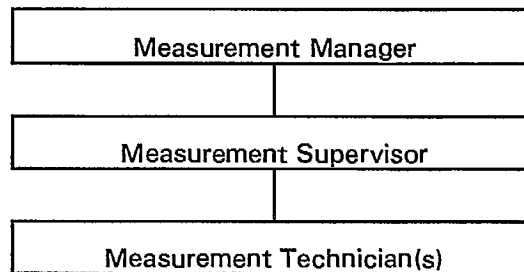
- (d) maintaining all quality records pertaining to the training of Program personnel and the performance of the work;
- (e) processing all nonconformance reports as they arise and deciding upon disposition and corrective action; and
- (f) ensuring that corrective actions are implemented in a timely manner and are effective.

**2.3.4 Measurement Technician**

The Measurement Technician is responsible for:

- (a) performing the conversion device firmware upgrade work and documenting the associated results in accordance with the procedures contained in this Manual;
- (b) evaluating the performance and conformance status of conversion devices both before and after the upgrade process and documenting the associated results in accordance with the procedures contained in this Manual;
- (c) identifying and formally reporting all nonconformances discovered during the conduct of the work; and
- (d) preparing, using, and maintaining the integrity while in his custody of all test and upgrading equipment and measurement standards in accordance with the procedures in this Manual and good measurement practice.

**2.4 Organization Chart**





### **3. PROCESS CONTROL**

#### **POLICY**

It is the policy of the Company to ensure that the work is planned, managed, and performed according to this procedure.

#### **ADMINISTRATIVE PROCEDURE**

##### **3.1 Purpose**

The purpose of this procedure is to identify and describe the key processes required by the Quality Program and to ensure that they are accomplished under controlled conditions by qualified personnel.

##### **3.2 Scope**

This procedure applies to the program planning, implementation, review, and records keeping activities involved in modifying the firmware and evaluating compliance of Mercury Instruments EC-AT conversion devices.

##### **3.3 References**

None.

##### **3.4 Definitions**

None.

##### **3.5 Procedure**

###### **3.5.1 *Management Planning Activities***

The following activities are performed by the Measurement Manager:

- (a) Identify and list the target population of devices requiring upgrade including details of device quantities, locations, identification numbers, years of Measurement Canada verification, and estimated operating pressures.
- (b) Identify the necessary human resources to manage and perform the upgrade work, including specifying a project leader and defining associated responsibilities.
- (c) Review Quality Program documentation and train the project leader with respect to Quality Program requirements in accordance with the procedure in section 8.

###### **3.5.2 *Management Implementation Activities***

The following activities are performed by the Measurement Supervisor:

- (a) Schedule and assign work to Measurement Technicians.

- (b) Select and train Measurement Technicians to perform the work in accordance with the procedure in section 8.
- (c) Document that training was provided to technicians and that the training was effective in accordance with the procedure in section 8.
- (d) Identify and acquire all equipment necessary to perform the work in accordance with the requirements of the individual Technical Procedures.

#### 3.5.3 *Technician Work Activities*

The following activities are performed by the Measurement Technician:

- (a) Prepare for use and take care of inspection and test equipment required to perform the work in accordance with the procedure in section 5.
- (b) Perform the upgrade of device firmware and inspect the compliance of conversion devices in accordance with the procedure in section 4.
- (c) Document the results of all firmware upgrade and inspection activities, including documenting nonconformance reports, in accordance with the procedure in section 4.
- (d) Submit documented reports for work completed to the Measurement Supervisor.

#### 3.5.4 *Management Review and Records Activities*

The following activities are performed by the Measurement Supervisor:

- (a) Review the results and reports of work performed and implement corrective action in accordance with the procedure of section 6.
- (b) Audit the work performed by Measurement Technicians.
- (c) Update and maintain quality records in accordance with the procedure in section 7.
- (d) Issue reports to and provide information requested by Measurement Canada representatives regarding program activities.

#### 3.6 **Documentation**

None.

## **4. MODIFICATION, INSPECTION, and TESTING**

### **POLICY**

It is the policy of the Company to ensure that the work is performed, inspected, and tested to meet Measurement Canada and Company requirements through the activities of this Quality Program.

### **ADMINISTRATIVE PROCEDURE**

#### **4.1 Purpose**

The purpose of this procedure is to define the steps to be followed by the Measurement Technician to modify device firmware and evaluate the compliance status of the device.

#### **4.2 Scope**

This procedure applies to the firmware upgrade, inspection, and testing activities for the Mercury Instruments EC-AT conversion device.

#### **4.3 References**

- 4.3.1 List of devices and device information produced in accordance with clause 3.5.1(a) of the Process Control administrative procedure.
- 4.3.2 Control of Inspection and Test Equipment administrative procedure (section 5).
- 4.3.3 Technical Procedure: Inspection of Mercury Instruments EC-AT Electronic Volume Conversion Device (Inspection at Operating Conditions).
- 4.3.4 Technical Procedure: Firmware Upgrade of Mercury Instruments EC-AT Electronic Volume Conversion Device (Version 3.10 to Version 5.23).
- 4.3.5 Technical Procedure: Firmware Upgrade of Mercury Instruments EC-AT Electronic Volume Conversion Device (Version 4.xx to Version 5.23).

#### **4.4 Definitions**

None.

#### **4.5 Procedure**

The following activities are performed by the Measurement Technician:

##### **4.5.1 Preparation**

- (a) Obtain the list identified in clause 4.3.1 for the devices to be upgraded.
- (b) Prepare the inspection, test, and firmware upgrade equipment for use in accordance with the procedure referred to in clause 4.3.2.

- (c) Ensure that the pressure standard is calibrated over the range of gas pressures expected to be encountered at the device locations based on the information contained in the list identified in clause 4.3.1.

#### 4.5.2 *As-Found Inspection and Test*

- (a) Verify that the company number and serial number of the selected device matches that on the list. Record any discrepancy on the list.
- (b) Verify that the device is functioning properly by scrolling through the device's displayed measurement values and noting whether any alarm conditions are indicated by the presence of "dots" on the display. Record the indication of any alarms and the action taken to resolve them on the device inspection form for management review.
- (c) Perform an as-found test of device quality in accordance with the procedure referred to in clause 4.3.3 and record all results on the associated inspection form.
- (d) If a nonconformance is discovered which cannot be corrected on site, discontinue this procedure and remove the device from service.

#### 4.5.3 *Firmware Upgrade*

- (a) Identify the device's present firmware version from the information obtained during device inspection.
- (b) If the firmware version is 3.10, perform the firmware upgrade in accordance with the procedure referred to in clause 4.3.4.
- (c) If the firmware version is 4.xx, perform the firmware upgrade in accordance with the procedure referred to in clause 4.3.5.
- (d) Ensure all steps and information are documented on the associated forms and that resulting electronic files are preserved.
- (e) If a nonconformance is discovered which cannot be corrected on site, discontinue this procedure and remove the device from service.

#### 4.5.4 *As-Left Inspection and Test*

- (a) Perform an as-left test of device quality in accordance with the procedure referred to in clause 4.3.3 and record all results on the associated inspection form.
- (b) Compare the as-left results with the as-found results and identify any discrepancies for management review on the inspection form.
- (c) If a nonconformance is discovered which cannot be corrected on site, discontinue this procedure and remove the device from service.

#### 4.6 **Documentation**

Refer to referenced technical procedures for required documentation.

## 5. CONTROL OF INSPECTION and TEST EQUIPMENT

### POLICY

It is the policy of the Company to ensure that all equipment and standards necessary for performing maintenance and quality control work are functional and suitable for the intended task.

### ADMINISTRATIVE PROCEDURE

#### 5.1 Purpose

The purpose of this procedure is to define the steps involved in controlling equipment and standards necessary for inspecting, testing, and modifying the firmware of conversion devices.

#### 5.2 Scope

This procedure applies to the equipment and standards used to upgrade the firmware and inspect and test the compliance of Mercury Instruments EC-AT conversion devices.

#### 5.3 References

5.3.1 List of devices and device information produced in accordance with clause 3.5.1(a) of the Process Control administrative procedure.

5.3.2 Technical Procedure: Calibration of Pressure and Temperature Standards

#### 5.4 Definitions

*Equipment:* any inspection or test equipment, including equipment to perform firmware upgrades, measurement standards, and associated supplies.

#### 5.5 Procedure

##### 5.5.1 *Identification and Acquisition of Equipment*

The following activities are performed by the Measurement Supervisor:

- (a) Review each technical procedure to identify the equipment and standards necessary to perform the work.
- (b) Acquire the required equipment and standards.

##### 5.5.2 *Preparation of Equipment*

The following activities are performed by the Measurement Technician:

- (a) Prepare all equipment prior to use as appropriate by:
  - (i) ensuring all required equipment and associated supplies are available;
  - (ii) ensuring all equipment is in working order;
  - (iii) charging the batteries of electronic equipment; and
  - (iv) installing and testing software functionality.

- (b) Notify the Measurement Supervisor of any deficiencies discovered during equipment preparation.

#### 5.5.3 *Calibration of Standards*

- (a) From the list referred to in clause 5.3.1, identify the range of operating pressures expected to be encountered for the devices to be serviced.
- (b) Calibrate the pressure standard over this range in accordance with the procedure referred to in clause 5.3.2.
- (c) Calibrate the temperature standard over the range of temperatures expected to be encountered in service in accordance with the procedure referred to in clause 5.3.2.
- (d) Document all calibration results.
- (e) Submit a copy of the documented calibration results to the Measurement Supervisor for quality records purposes.

#### 5.5.4 *Use and Maintenance of Equipment*

The following activities are performed by the Measurement Technician:

- (a) Identify the conditions, environmental or otherwise, required for equipment to function properly based on manufacturer's specifications.
- (b) Use the equipment within the conditions identified in step (a).
- (c) Use standards within their calibrated ranges, and ensure corrections are applied to readings to adjust for any systematic errors.
- (d) Check the performance of the standards following use to ensure characteristics have remained stable during use. Notify the Measurement Supervisor of any change in performance for management review.
- (e) Maintain the integrity of equipment by handling and storing it in manner to prevent damage or alteration of characteristics during transportation or otherwise.

#### 5.6 **Documentation**

Refer to referenced technical procedures for required documentation.

## 6. CORRECTIVE ACTION

### POLICY

It is the policy of the Company to ensure that all nonconformances associated with the administration of the Quality Program are identified, documented, and effectively dispositioned and corrected and that steps are taken to prevent their recurrence.

### ADMINISTRATIVE PROCEDURE

#### 6.1 Purpose

The purpose of this procedure is to define the steps to be taken to identify and correct nonconformances.

#### 6.2 Scope

This procedure applies to the identification and correction of all nonconformances pertaining to the administration of the Quality Program.

#### 6.3 References

None.

#### 6.4 Definitions

*Disposition:* an action taken to resolve a nonconformance.

*Nonconformance:* any deficiency in characteristic, documentation, or procedure which renders the quality of a product, service, or activity unacceptable with respect to the associated requirements.

#### 6.5 Procedure

##### 6.5.1 *Nonconformance Identification*

The following activities are performed by any personnel discovering a nonconformance:

- (a) For each nonconformance discovered, document details describing the nonconformance, including the associated Quality Program Manual reference and the activity in which the nonconformance was found, on the form referred to in clause 6.6.1.
- (b) Include in the report the details of any disposition taken at the time of the nonconformance's discovery.
- (c) Assign a unique identification number to, sign, and date the report.
- (d) Submit the report to the Measurement Supervisor for processing.

### 6.5.2 *Corrective Action Development*

The following activities are performed by the Measurement Supervisor:

- (a) Analyze the nonconformance and any disposition taken to determine whether further steps must be taken to resolve the immediate nonconformance.
- (b) In the case of nonconformance with respect to the approval or verification status of a device, promptly notify Measurement Canada as a step in resolving the nonconformance.
- (c) Document any steps resulting from the analysis in the report and implement these steps.
- (d) Establish the cause of the nonconformance and develop a corrective action to prevent its recurrence.
- (e) Review other areas of the Quality Program which may be affected by the type of nonconformance discovered and develop a corrective action as appropriate.
- (f) Document the corrective actions developed in steps (d) and (e) above in the report.

### 6.5.3 *Corrective Action Implementation*

The following activities are performed by the Measurement Supervisor:

- (a) Implement the corrective actions developed in clause 6.5.2 and monitor progress.
- (b) Verify that corrective actions have been implemented and are effective and document this verification in the report.
- (c) Complete the report and process it according to the procedure in section 7.

## 6.6 **Documentation**

### 6.6.1 Appendix A. Nonconformance and Corrective Action Report



## **7. QUALITY RECORDS**

### **POLICY**

It is the policy of the Company to ensure that quality records are created and maintained for the Quality Program activities.

### **ADMINISTRATIVE PROCEDURE**

#### **7.1 Purpose**

The purpose of this procedure is to describe the steps followed in creating and maintaining quality records.

#### **7.2 Scope**

This procedure applies to all records generated by activities associated with the implementation and administration of the Quality Program.

#### **7.3 References**

None.

#### **7.4 Definitions**

None.

#### **7.5 Procedure**

##### **7.5.1 *Records Creation***

(a) The following activities are performed by the Measurement Manager:

- (i) Create records identifying the devices requiring processing under the Quality Program, including associated device details, in accordance with clause 3.5.1(a).
- (ii) Create records demonstrating that the review and training activities required in clause 8.5.1 have been met.
- (iii) Submit all records to the Measurement Supervisor.

(b) The following activities are performed by the Measurement Supervisor:

- (i) Create records demonstrating that personnel selection criteria and the review and training activities required in clause 8.5.2 have been met.
- (ii) Create records demonstrating that auditing work required in clause 3.5.4(b) has been performed and documenting audit results.
- (iii) Create records for each corrective action developed and implemented to resolve a nonconformance.

(c) The following activities are performed by the Measurement Technician:

- (i) Create records demonstrating that all standards used for inspecting conversion device quality have been properly calibrated before use.

- (ii) Create records demonstrating that firmware upgrading procedure has been properly implemented for each conversion device processed.
- (iii) Create records demonstrating that the inspection procedure has been properly implemented for each conversion device processed.
- (iv) Create records for each nonconformance discovered during the implementation of Quality Program activities.
- (v) Where applicable, create records for each corrective action developed and implemented to resolve a nonconformance.
- (vi) Submit all records to the Measurement Supervisor.

#### 7.5.2 *Records Review*

The following activities are performed by the Measurement Supervisor:

- (a) Review all records for compliance with the requirements of the Quality Program documentation.
- (b) Indicate within the records that the review in step (a) has been performed.

#### 7.5.3 *Records Maintenance*

The following activities are performed by the Measurement Supervisor:

- (a) Update the records system to include new records as they are received.
- (b) File paper and electronic records in a cross-referenced manner to facilitate retrieval.
- (c) Store paper and electronic records in a manner which prevents deterioration or loss.
- (d) Maintain records in a readily-accessible form for a period of one year from date of their creation.

#### 7.6 **Documentation**

None.

## **8. TRAINING**

### **POLICY**

It is the policy of the Company to ensure that all personnel involved in the Quality Program are adequately trained and informed in regard to their duties and responsibilities and are capable of performing their assigned work.

### **ADMINISTRATIVE PROCEDURE**

#### **8.1 Purpose**

The purpose of this procedure is to describe the training process for personnel involved in the Quality Program activities.

#### **8.2 Scope**

This procedure addresses the training and information needs for the Measurement Manager, the Measurement Supervisor, and the Measurement Technicians.

#### **8.3 References**

None.

#### **8.4 Definitions**

None.

#### **8.5 Procedure**

##### **8.5.1 *Management Training***

The following activities are performed by the Measurement Manager:

- (a) Review the details of this Quality Program Manual, and consult as necessary with Canadian Gas Association and Measurement Canada authorities to ensure complete understanding of the program.
- (b) Train the Measurement Supervisor with respect to his responsibilities in the Quality Program by jointly reviewing the entire Quality Program Manual and confirming understanding following the review.
- (c) Record information confirming that review and training in steps (a) and (b) were performed and were successful on the form identified in 8.6.1 and file the form in the quality records.

### 8.5.2 *Technician Training*

The following activities are performed by the Measurement Supervisor:

- (a) Select Measurement Technicians to perform the work who have an extensive background in gas metering and have demonstrated capability in the maintenance of gas measuring equipment including metering, valving, charting, electronic conversion devices, and modems. The selected Technicians will have demonstrated attention to detail in their daily work routines which includes the maintenance of gas metering stations according to the prescribed Company standards and the troubleshooting of related equipment including electronic conversion devices.
- (b) Train the Measurement Technicians with respect to their responsibilities in the Quality Program by:
  - (i) jointly reviewing the entire Quality Program Manual to ensure a contextual understanding;
  - (ii) reviewing in detail the Inspection and Testing, Control of Inspection and Test Equipment, and Technical Procedures portions of the Manual to ensure that the Mercury EC-AT conversion device performance and conformance testing procedures, firmware upgrading procedures, and report forms are fully understood; and
  - (iii) providing hands-on demonstrations of the use of the computer hardware and software to perform the firmware upgrade and of the use of the measurement standards to test device performance.
- (c) Test each Measurement Technician on his ability to follow the technical procedures, to test and perform a firmware upgrade on a Mercury EC-AT conversion device, and to demonstrate a thorough understanding of the importance of the Quality Program.
- (d) Record information that the Measurement Technician meets the selection criteria, has received the defined training, and has passed the testing criteria on the training and qualifications form identified in clause 8.61 and file the form in the quality records.

## 8.6 **Documentation**

### 8.6.1 Appendix B. Personnel Training and Technician Qualifications Form

TECHNICAL PROCEDURES

CONTENTS

1. Calibration of Pressure and Temperature Standards
2. Inspection of Mercury Instruments EC-AT Electronic Volume Conversion Device (Inspection at Operating Conditions)
3. Firmware Upgrade of Mercury Instruments EC-AT Electronic Volume Conversion Device (Version 3.10 to Version 5.23).
4. Firmware Upgrade of Mercury Instruments EC-AT Electronic Volume Conversion Device (Version 4.xx to Version 5.23).

**Technical Procedure 1**  
**Calibration Procedure**  
**Pressure and Temperature Standards**

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2. Scope
3. References
4. Definitions
5. Apparatus
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  - 6.3 *Pressure Standard Calibration*
  - 6.4 *Temperature Standard Calibration*
  - 6.5 *Calculation of Errors*
  - 6.6 *Completion of Calibration Documentation*
7. Documentation

**1. Purpose**

The purpose of this procedure is to provide instruction for the calibration of pressure and temperature standards.

**2. Scope**

This procedure applies to calibration of pressure and temperature standards used to inspect the performance of Mercury Instruments EC-AT electronic volume conversion devices.

**3. References**

3.1 Control of Inspection and Test Equipment administrative procedure (section 5).

**4. Definitions**

4.1 *Working standard*: a standard which is calibrated against a reference standard and is intended to be used to inspect ordinary measuring devices.

4.2 *Reference standard*: a standard which is calibrated and certified against a primary standard and is intended to be used to calibrate working standards.

**5. Apparatus**

**5.1 Measurement Standards**

(a) Reference pressure standard, certified at pressures over the conversion device's operating range.

(b) Reference temperature standard, certified at temperatures over the conversion device's operating range.

**5.2 Test Equipment**

(a) Pressure gauge test assembly, with variable pressure supply.

(b) Temperature bath, with variable settings.

**6. Procedure**

**6.1 Administrative Information Capture**

(a) Record the identification numbers of the working standards and reference standards on the calibration form referred to in clause 7.1.

(b) Record the name of the person performing the calibration and the date the calibration was performed on the calibration form.

(c) Establish at least three pressure values over the range determined in clause 5.5.3(a) of the procedure referenced in clause 3.1 above to be used as calibration points and record these nominal values on the calibration form.

- (d) Establish at least three temperature values over the range determined in clause 5.5.3(c) of the procedure referenced in clause 3.1 above to be used as calibration points and record these nominal values on the calibration form.

#### 6.2 *Visual Examination*

- (a) Examine the working standards to ensure that they are in operating condition and functional, and that their designed pressure or temperature ranges are compliant with the range of values determined in clause 6.1(c) or 6.1(d), as the case may be. Identify and record any deficiency as a nonconformity on the calibration form. Suspend further calibration activity if any nonconformity is found.
- (b) Examine the reference standards to ensure that they are in operating condition and functional, and that they have been certified to Measurement Canada requirements. Identify and record the absence of any deficiency as a nonconformity on the calibration form. Suspend further calibration activity if any nonconformity is found.

#### 6.3 *Pressure Standard Calibration*

- (a) Connect the pressure working standard to be calibrated and the reference pressure standard to the test assembly.
- (b) Slowly increase the pressure supply until the value displayed by the reference pressure standard corresponds to the minimum of the established pressure calibration points.
- (c) Record the values displayed by the pressure working standard and the reference standard on the calibration form.
- (d) Repeat steps (b) and (c) for each of the remaining established pressure calibration points.
- (e) Slowly increase the supplied pressure to a value in excess of the maximum established pressure calibration point as preparation for downscale tests.
- (f) Slowly decrease the pressure supply until the value displayed by the reference pressure standard corresponds to the maximum of the established pressure calibration points.
- (g) Record the values displayed by the pressure working standard and the reference standard on the calibration form.
- (h) Repeat steps (f) and (g) for each of the remaining established pressure calibration points.
- (i) Slowly decrease the supplied pressure to zero.
- (j) Disconnect the pressure working standard from the test assembly and store it in its carrying case.
- (k) Return the reference standard and test assembly to its storage environment.

#### 6.4 *Temperature Standard Calibration*

- (a) Immerse the sensor of the temperature standard to be calibrated and the sensor of the reference temperature standard in the temperature bath.



- (b) Adjust the temperature bath's control to correspond to the minimum of the established temperature calibration points.
- (c) Wait until the bath temperature and the readings of the standards stabilize.
- (d) Record the values displayed by the working standard and the reference standard on the calibration form.
- (e) Repeat steps (b), (c), and (d) for each of the remaining established temperature calibration points.
- (f) Remove the working standard from the bath and store it in its carrying case.
- (g) Return the reference standard and temperature bath to its storage environment.

6.5 ***Calculation of Errors***

- (a) For each nominal value specified for the pressure working standard, calculate the average of the upscale and downscale values displayed by each of the standards and record these values on the calibration form.
- (b) Calculate the signed difference between each pair of averaged values determined in step (a) and record these values as the errors of the pressure standard on the calibration form.
- (c) For each nominal value specified for the temperature working standard, calculate the signed difference between values displayed by the working standard and reference standards and record these values as the errors of the temperature standard on the calibration form.

6.6 ***Completion of Calibration Documentation***

- (a) Complete the calibration form by adding any final observations or comments and signing the form.
- (b) Prepare a nonconformance report for any nonconformities noted during the calibration.
- (c) Ensure that all completed forms and reports are submitted to the Measurement Supervisor.

7. **Documentation**

7.1 Appendix C. Pressure and Temperature Standard Calibration Form

## Technical Procedure 2

### Inspection of Mercury Instruments EC-AT Electronic Volume Conversion Device

#### (Inspection at Operating Conditions)

#### Contents

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6. Procedure
  - 6.1 *Set-up*
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  - 6.3 *Visual Examination*
  - 6.4 *Dynamic Performance Information Capture*
  - 6.5 *Pressure Conversion Function Tests*
  - 6.6 *Temperature Conversion Function Tests*
  - 6.7 *Supercompressibility Correction Function Tests*
  - 6.8 *Volume Conversion Accuracy*
  - 6.9 *Test Completion*
  - 6.10 *Completion of Inspection Documentation*
7. Documentation

1. **Purpose**

The purpose of this procedure is to provide instruction for the inspection of the quality characteristics of electronic volume conversion devices in order to establish their conformance with specification requirements.

2. **Scope**

This procedure applies to inspection at the operational location of gauge pressure versions of Mercury Instruments EC-AT electronic volume conversion devices.

3. **References**

- 3.1 Measurement Canada specifications for conversion device verification and reverification (summary contained in the reference in clause 7.1).
- 3.2 Measurement Canada authorized software for calculating supercompressibility values.
- 3.3 Measurement Canada Notice of Approval AG-0242.
- 3.4 Inspection and Testing Administrative Procedure (Program Policies and Procedures, section 4).

4. **Definitions**

- 4.1 *Conversion device*: a device which converts volumes of gas measured at one set of conditions to equivalent volumes of gas at another set of conditions.
- 4.4 *Dynamic information*: any information which changes instantaneously with changes in the flowing gas conditions.
- 4.5 *Static information*: any information which is either permanently fixed or requires manual intervention to be changed.
- 4.6 *Pressure multiplier (Pm)*: a multiplier which when applied to units of gas volume at line pressure converts the volume to equivalent units at a different base pressure. The multiplier is a function of the atmospheric pressure (*Patm*), the gauge pressure (*Pg*) of the gas, and the base pressure (*Pb*), and is expressed mathematically as:

$$Pm = \frac{Patm + Pg}{Pb}$$

- 4.7 *Temperature multiplier (Tm)*: a multiplier which when applied to units of gas volume at line temperature converts the volume to equivalent units at a different base temperature. The multiplier is a function of the gauge temperature (*Tg*) of the gas and the base temperature (*Tb*), both expressed on the Fahrenheit scale, and is expressed mathematically as:

$$Tm = \frac{Tb + 459.67}{Tg + 459.67}$$

4.8 **Supercompressibility multiplier ( $S_m$ ):** a multiplier which when applied to units of gas volume at base pressure and temperature corrects the volume to reflect actual gas parameters. The multiplier is a function of the gauge pressure and temperature of the gas and the molecular composition of the gas. This multiplier is equal to the squared value of the supercompressibility factor.

4.9 **Volume multiplier ( $V_m$ ):** a multiplier which when applied to units of gas volume at line pressure and temperature converts the volume to equivalent units at a different base pressure and temperature. The multiplier is the product of the pressure multiplier ( $P_m$ ), temperature multiplier ( $T_m$ ), and supercompressibility multiplier ( $S_m$ ), and is expressed mathematically as:

$$V_m = P_m \times T_m \times S_m$$

## 5. Apparatus

### 5.1 Measurement Standards

- (a) Pressure gauge, calibrated at gauge pressures over the conversion device's operating range.
- (b) Thermometer, calibrated at temperatures over the conversion device's operating range.

### 5.2 Test Equipment

- (a) Pressure fittings and hoses with safety ratings in excess of required test pressures for the conversion device.
- (b) Teflon tape and necessary tools for connecting the conversion device to the measurement standards and test equipment.
- (c) Scientific calculator or computer capable of making all necessary calculations, including supercompressibility value determination.

## 6. Procedure

### 6.1 Set-up

- (a) Review the manufacturer's reference manual for the device to familiarize yourself with the device's features and for details on accessing measurement-related information.
- (b) Review the summary of specification requirements referred to in clause 7.1 to familiarize yourself with Measurement Canada's verification and reverification requirements for the device.
- (c) Connect the measurement standards and test equipment to the device in accordance with the test set-up diagram referred to in clause 7.2, ensuring that all connections are sound and that the device and standards are not subjected to any mechanical shock.
- (d) Configure the device for testing in accordance with the manufacturer's procedure identified in item (a) above.

## 6.2 *Static and Dynamic Information Capture*

- (a) Record the following general administrative data on the inspection form referred to in clause 7.3:
- date of inspection
  - address of test location
  - identification numbers of all standards
  - the name of the person performing the inspection
- (b) Record the following administrative data from information marked on (or programmed into) the conversion device and its associated transducers on the inspection form:
- manufacturer
  - model designation
  - government approval number
  - inspection number
  - serial number (item 62)
  - base temperature (item 34)
  - base pressure (item 13)
  - atmospheric pressure (item 14)
  - pressure conversion function's designed operating range
  - volumetric input specification (e.g., volume per input revolution)
  - firmware version number (item 122)
  - main battery voltage (item 48)
  - memory battery voltage (item 51)
- (c) Record the following measurement data from information displayed by or programmed into the conversion device on the inspection form:
- corrected volume (item 0)
  - uncorrected volume (item 2)
  - pressure (item 8)
  - temperature (item 26)
  - carbon dioxide value (item 55)
  - nitrogen value (item 54)
  - relative density value [specific gravity] (item 53)
  - volume multiplier [total correction factor] (item 43)
  - pressure multiplier [pressure correction factor] (item 44)
  - temperature multiplier [temperature correction factor] (item 45)
  - supercompressibility multiplier (item 116)

### 6.3 *Visual Examination*

- (a) Examine the device for conformity with the Measurement Canada Notice of Approval description, ensuring that the operating pressure and temperature are within the device's designed operating ranges. Identify and record any deviation as a nonconformity on the inspection form. Suspend further inspection if any nonconformity is found.
- (b) Examine the device for an indication of a Measurement Canada verification and record the indicated verification year. Identify and record the absence of a verification mark as a nonconformity on the inspection form. Suspend further inspection if this nonconformity is found.
- (c) Examine the device for any defects in workmanship which could affect the device's ability to reliably meet specification requirements while in use. Identify and record any such defect as a nonconformity on the inspection form.
- (d) Examine the electronic display to ensure that all segments of the display are properly functioning. Record any defect as a nonconformity on the inspection form.
- (e) Examine the mechanical register to ensure that all pointers or drums are properly aligned. Record any defect as a nonconformity on the inspection form.

### 6.4 *Dynamic Performance Information Capture*

- (a) Access the device's measurement registers from the keypad and read and record the following measurement data on the inspection form:
  - gas gauge pressure (item 8)
  - atmospheric pressure (item 14)
  - base pressure (item 13)
  - pressure multiplier (item 44)
  - gas temperature (item 26)
  - base temperature (item 34)
  - temperature multiplier (item 45)
  - supercompressibility multiplier (item 116)
  - overall volume multiplier (item 43)
- (b) Read the values of gauge pressure and temperature displayed by the standards and record these values on the inspection form.
- (c) Note whether gas was flowing through the meter during the information capture process and record this observation on the inspection form.

### 6.5 *Pressure Conversion Function Evaluation*

- (a) Calculate the apparent pressure multiplier based on the values displayed by the device for gauge pressure, atmospheric pressure, and base pressure in accordance with the equation in clause 4.6 and compare this calculation to the displayed pressure multiplier. Record these values on the inspection form and, if there is a difference between the two values, record this finding as a nonconformity.

- (b) Calculate the true pressure multiplier based on the gauge pressure displayed by the standard (corrected for the standard's systematic error) and the values displayed by the device for atmospheric pressure and base pressure in accordance with the equation in clause 4.6. Record the true pressure multiplier and the relative error of the apparent pressure multiplier on the inspection form.
- (c) If the relative error exceeds  $\pm 1.0\%$ , record this finding as a nonconformity. If the relative error exceeds  $\pm 0.6\%$ , record an indication on the form that the device requires management review.

#### 6.6 *Temperature Conversion Function Evaluation*

- (a) Calculate the apparent temperature multiplier in accordance with the equation in clause 4.7 based on the values displayed by the device for gauge temperature and base temperature and compare this calculation to the displayed temperature multiplier. Record these values on the inspection form and, if there is a difference between the two values, record this finding as a nonconformity.
- (b) Calculate the true temperature multiplier in accordance with the equation in clause 4.7 based on the gauge temperature displayed by the standard (corrected for the standard's systematic error) and the value displayed by the device for base temperature. Record the true temperature multiplier and the relative error of the apparent temperature multiplier on the inspection form.
- (c) If the relative error exceeds  $\pm 1.0\%$ , record this finding as a nonconformity. If the relative error exceeds  $\pm 0.6\%$ , record an indication on the form that the device requires management review.

#### 6.7 *Supercompressibility Correction Function Evaluation*

- (a) Calculate the true supercompressibility multiplier in accordance with the software referred to in clause 3.2 based on the values displayed by the device for pressure, temperature, relative density, nitrogen content, and carbon dioxide content and compare this calculation to the displayed value of the squared supercompressibility factor. Calculate the relative error of the displayed value. Record these values and calculations on the inspection form.
- (b) If the relative error exceeds  $\pm 0.3\%$ , record this finding as a nonconformity.

#### 6.8 *Volume Conversion Accuracy*

- (a) From the data obtained in clauses 6.5 to 6.8, calculate the product of the displayed values for the pressure multiplier, the temperature multiplier, and the squared supercompressibility factor and compare this value to the displayed total correction factor. Record these values on the inspection form and, if there is a difference between the two values, record this finding as a nonconformity.
- (b) From the data obtained in clauses 6.5 to 6.8, calculate the sum of the pressure multiplier relative error, the temperature multiplier relative error, and the supercompressibility multiplier relative error and record this sum on the inspection form as the volume multiplier relative error.

- (c) If the volume multiplier relative error exceeds  $\pm 1.6\%$ , record this finding as a nonconformity on the inspection form. If the relative error exceeds  $\pm 1.0\%$ , record an indication on the form that the device requires management review.

**6.9 Test Completion**

- (a) Disconnect the standards from the device.
- (b) Restore the device to a secure state preventing unauthorized access.

**6.10 Completion of Inspection Documentation**

- (a) Complete the inspection form by adding any final observations and signing the form.
- (b) Prepare a nonconformance report for any nonconformities noted during the inspection.
- (c) Ensure that all completed forms and reports are submitted to the Measurement Supervisor.

**7. Documentation**

7.1 Appendix D. Summary of Conversion Device Specification Requirements

7.2 Appendix E. Conversion Device Test Set-up Diagram

7.3 Appendix F. EC-AT Device Inspection Form



## Technical Procedure 3

### Firmware Upgrade of Mercury Instruments EC-AT Electronic Volume Conversion Device

(Version 3.10 to Version 5.23)

#### Contents

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  - 6.2 *Preparation and Set-up*
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  - 6.4 *Instrument Shutdown*
  - 6.5 *Firmware Replacement*
  - 6.6 *Instrument Reconfiguration*
  - 6.7 *Instrument Data Upload and Updating*
  - 6.8 *Verification of Successful Upgrade*
  - 6.9 *Instrument Recommissioning*
  - 6.10 *Documentation Completion*
7. Documentation

**1. Purpose**

The purpose of this procedure is to provide instruction for upgrading the firmware of a Mercury Instruments EC-AT electronic volume conversion device to firmware version 5.23.

**2. Scope**

This procedure applies to Mercury Instruments EC-AT devices which are programmed with version 3.10 firmware.

**3. References**

3.1 Mercury Instruments EC-AT Operations Manual.

3.2 Mercury Instruments AT Link for Windows software manual (electronic version).

**4. Definitions**

4.1 DCU: Data Control Unit.

4.2 PROM: Programmable read-only memory.

**5. Apparatus**

The following equipment is required to perform the firmware upgrade:

- (a) Laptop computer with a minimum of an 80486 processor and 8 MB of RAM, using a Windows operating system (Windows 3.1, 95, or NT). Note that 16 MB of RAM is required if Windows 95 or NT operating systems are used.
- (b) Mercury Instruments EC-AT version 5.23 firmware PROMs.
- (c) Mercury Instruments AT Link for Windows software, version 5.25 or higher.
- (d) PROM chip puller.
- (e) Mercury Instruments I/O cable, part number 40-1629.
- (f) Mercury Instruments diskette containing pressure transducer coefficients for the specific EC-AT device to be upgraded.
- (g) Diskette for data storage.
- (h) Mercury Instruments EC-AT replacement memory battery.

**6. Procedure**

Document the successful completion of each of the procedural steps below including any relevant comments on the form identified in clause 7.1.

**6.1 *Measurement Data Capture***

**6.1.1 Review instrument measurement features**

- (a) Familiarize yourself with the features and operations of the EC-AT instrument by reviewing the manual referred to in clause 3.1.

- (b) Note procedure to access stored measurement data from the device's keypad, which is as follows:
- (i) Press the "MI" button.
  - (ii) Enter the access code "11111" (five 1's), and then press "ENTR".
  - (iii) When the lower displays "Select Function", press the "DISP" button.
  - (iv) Enter the item number followed by a press of the "ENTR" button to display the measurement data for that item.
  - (v) If data for another item is required, repeat step (iv).
  - (vi) Press the "EXIT" button twice to return the device to Corrector mode.

#### 6.1.2 Read and record critical measurement data

Using the steps in clause 6.1.1(b), access the following measurement data according to its item number and record the values on the form identified in clause 7.2:

- (a) Corrected volume (item 0).
- (b) Uncorrected volume (item 2).
- (c) Firmware version (item 122).
- (d) Pressure (item 8).
- (e) Temperature (item 26).
- (f) Instrument serial number (item 62).
- (g) Total correction factor (item 43).
- (h) Squared supercompressibility factor (item 116).
- (i) Specific gravity (item 53).
- (j) % N2 for supercompressibility (item 54).
- (k) % CO2 for supercompressibility (item 55).
- (l) Local atmospheric pressure (item 14), [for gauge transducers only].
- (m) Main battery voltage (item 48).
- (n) Memory battery voltage (item 51).

#### 6.1.3 Read and record optional measurement data

For devices equipped with a pulse output board, access the following additional items of measurement data and record the values on the form identified in clause 7.2:

- (a) Pulse Output A Scaling Factor (item 56).
- (b) Pulse Output B Scaling Factor (item 57).
- (c) Pulse Output C Scaling Factor (item 58).

### 6.2 *Preparation and Set-up*

#### 6.2.1 Prepare computer for use

- (a) Install the AT-Link for Windows software on the computer to be used and verify its functionality.
- (b) Familiarize yourself with the software's operation by reviewing the manual referred to in clause 3.2.
- (c) Verify that the computer's internal date and time are accurate; correct as necessary through operating system commands.
- (d) Connect the computer's COM port to the RS-232 serial port on back of EC-AT device using the I/O cable referred to in clause 5(e).

### 6.2.2 Verify transducer serial number

- (a) Verify that the transducer serial number on the label of upper chip matches the serial number on transducer label. (Note: The transducer is located in the lower left corner of instrument case.)
- (b) If a list of instrument serial numbers is provided by Mercury Instruments, locate the transducer serial number on list and mark it as verified.

### 6.2.3 Verify firmware version is 3.10

- (a) Open the instrument door and swing open the keypad assembly.
- (b) Remove the aluminum plate covering the main circuit board.
- (c) Locate the firmware chip which is the lower of the two IC PROM chips near the upper left-hand corner of the main circuit board (with white adhesive labels) and record the version number printed on the label.
- (d) If the firmware version is not on the PROM label, it can be identified through Item 122 in the instrument's Item list by performing the following steps:
  - (i) Access instrument through the keypad by pressing "MI".
  - (ii) Enter the access code "11111" (five 1's), and then press "ENTR".
  - (iii) Press "DISP", then access Item #122 by entering "122" followed by "ENTR". The top LCD will display "3.10", and lower LCD will display "FIRMWARE".
  - (iv) Press "EXIT" twice to return to Corrector Mode.

## 6.3 *Instrument Data Download*

### 6.3.1 Configure DCU report format (header, body, and item list)

- (a) To 'wake up' instrument, press "MI" on keypad.
- (b) Enter the access code "11111", and then press "ENTR".
- (c) Press "DISP".
- (d) Access Item # 227 by pressing "227", followed by "ENTR".
- (e) Press "CHNG", "7", and then "ENTR".
- (f) Press "EXIT" twice to return to Corrector Mode.

### 6.3.2 Download instrument data using AT-Link software

- (a) Start the AT-Link software.
- (b) Enter the User Access Code "22222" (five 2's), then select "OK".
- (c) From the software's main menu, select "SETUP" and then select "SITE LIST".
- (d) Add the site location for the instrument to be converted. (Note: The site information and audit trail information will be placed in the AT-Link database.)
- (e) If not already present, set the "Site ID Number" register (item 200) to the instrument's serial number and the "Site ID Number Part 2" register (item 201) to the company's number for the instrument.
- (f) From the software's main menu, select "File".
- (g) Select "Download/Convert DCU Protocol".
- (h) When prompted "Do you want to download a new file from the instrument?", select "Yes".
- (i) When prompted "Do you want to save the transferred file?" Select "Yes".
- (j) When prompted "Enter file name and path to save to", type in the 7-digit instrument serial number as the file name and then select "OK". DCU information will be saved in the data file format (\*.dat).
- (k) Read and confirm understanding of the "DCU File Conversion" form. Select "OK", and then wait until the transfer is complete.

- (l) When prompted "Enter file name and path to save to", type in the 7-digit instrument serial number as a file name and then select "OK". (Note: This will save the information identified referred to in clause 7.3 in the item file format (\*.itm).)
- (m) After the download is complete, you will be prompted for the filename for the converted item file. Type in the 7-digit instrument serial number as the file name and select "OK". This will save the item information in the authorizations file format (\*.ath).

#### 6.4 *Instrument Shutdown*

6.4.1 Record the instrument's mechanical index reading before proceeding with shutdown.

6.4.2 Decommission instrument

- (a) **Important:** *Unplug the index switch cable (white plug) from the input switch board. DO NOT plug index switch cable back in until that step is reached in clause 6.9.2.*
- (b) Access instrument through keypad, press "MI".
- (c) Enter access code "11111", press "ENTR".
- (d) At "SELECT FUNCTION", press "AUX" three times.
- (e) When the lower LCD displays "SHUTDOWN?", press "YES".
- (f) When the lower LCD displays "ARE YOU SURE?", press "YES".
- (g) Unplug the main battery cable.

6.4.3 Remove the memory battery from main circuit board

- (a) Remove memory battery, using the PROM puller if necessary.
- (b) Remove silicone RTV if still present on memory battery.

#### 6.5 *Firmware Replacement*

6.5.1 Remove both PROM chips from their sockets

Note: The upper chip is the "Char" PROM and contains transducer characterization information; the lower chip is the "Firmware" PROM.

- (a) Using the PROM puller tool, carefully remove both PROM chips.
- (b) Place the PROM chips in a protective sleeve or case for return to the Measurement Supervisor.

6.5.2 Install new firmware chips

- (a) Note that the PROM marked "2 UPPER" is to be installed in the upper socket and the PROM marked "1 LOWER" is to be installed in the lower socket.
- (b) Install both PROM chips with the notch positioned to the left (or outside edge), inserting one row of the chip's pins are in the appropriate socket, then tipping the chip until the other row of pins is in the socket.
- (c) If PROMs are difficult to insert into socket, slightly roll/bend pins together by pressing each side of the chip on a clean flat surface and repeat step (b).
- (d) Before continuing, double check both PROM chips for:
  - (i) Proper location.
  - (ii) Installation with notch to left.
  - (iii) All pins are in their socket holes and not bent under the body of the chip.

## 6.6 *Instrument Reconfiguration*

### 6.6.1 Re-install instrument batteries

- (a) If the memory battery voltage recorded in step 6.1.2(m) is less than 3 V (dc), use the replacement memory battery and dispose of the old battery.
- (b) Use the white silk-screen outline as guide for proper battery orientation while installing. (Note: It may be necessary to bend the battery leads slightly to create a snug fit.)
- (c) Except for the Index Switch Input Cable, make sure all cable connectors are properly seated.
- (d) Plug in the memory battery.
- (e) Plug in the main battery.

### 6.6.2 Configure instrument with factory default settings

- (a) Press the "MI" button on instrument keypad.
- (b) Check that the lower LCD displays "UNCONFIGURED".
- (c) If the lower LCD does not display "UNCONFIGURED", unplug the main battery and memory battery for 1 minute and start again at step 6.6.1.
- (d) Enter access code "21111" (top LCD will display five dashes "- - - - -") and press "ENTR".
- (e) When the lower LCD displays "SELF TEST?", press "YES".
- (f) When the lower LCD displays "ARE YOU SURE?", press "YES".
- (g) Verify that lower LCD displays says "SELF TEST OK".
- (h) If unit times out (i.e., both LCDs go blank), repeat the above steps starting at step (a) until successful.
- (i) If the instrument does not display "SELF TEST" within a short period of time (approximately 1 or 2 minutes maximum) or stays on "---TESTING---" for an unreasonably long period of time, check to make sure the PROM pins are inserted properly, otherwise continue with step (j).
- (j) Verify that the top LCD displays "22222" and lower LCD displays "CNFG ACCESS CODE", then press "YES".
- (k) Verify that the top LCD displays "11111" and lower LCD displays "CAL ACCESS CODE", then press "YES".
- (l) Verify that the top LCD displays "0" and lower LCD displays "EVENTLOG USER ID", then press "YES".
- (m) Press "EXIT" twice to return the instrument to Corrector mode.

## 6.7 *Instrument Data Upload and Updating*

### 6.7.1 Upload calibration and non-calibration item files

- (a) Ensure that the serial I/O cable is connected between the communications ports of the instrument and the laptop computer.
- (b) From the AT-Link software's main menu, choose "Transfer".
- (c) Select "Send Cal Items".
- (d) When prompted "Are You Sure You Want To Send Cal Items To The Instrument?", select "Yes".
- (e) Wait for prompt "Select An Item File to Send Calibration Items".
- (f) Insert the diskette with pressure coefficients into drive "A".
- (g) Change drive selection to "A".
- (h) Highlight the correct transducer number from the list and select OK.
- (i) Wait until transfer is complete, the green progress bar will be completely filled in.
- (j) Select "Exit".
- (k) Choose "Transfer". Choose "Exit" after successful transfer.

- (l) Select "Send Non-Cal Items".
- (m) When prompted "Are You Sure You Want To Send Non Cal Items To The Instrument ?", select "Yes".
- (n) When prompted "Select An Item File to Send Non Calibration Items", select the ".itm" file with the matching instrument serial number.
- (o) Wait until transfer is complete, the green progress bar will be completely filled in.
- (p) Select "Exit".
- (q) From the AT-Link software's main menu, choose "Transfer".
- (r) Select "Send Authorization Table".
- (s) When prompted "Are You Sure You Want To Send An Authorization Table To The Instrument ?", select "Yes".
- (t) When prompted "Select A File to Send Authorization Table Items", select the ".ath" file with the matching instrument serial number.
- (u) Wait until transfer is complete, the green progress bar will be completely filled in.
- (v) Select "Exit".

#### 6.7.2 Verify the instrument's date and time

- (a) From the AT-Link software main menu, choose "File".
- (b) Select "Set Inst. Date/Time via Computer".
- (c) When prompted "You are about to update the instruments clock to MM/DD/YY hh:mm:ss", select "OK" if the displayed computer date and time are correct.
- (d) If the displayed date or time is incorrect, select "Cancel" and change the instrument time and date using the Binocular icon feature for items 203 and 204.

#### 6.7.3 Verify corrected and uncorrected volume values

- (a) From the AT-Link software main menu, choose "Display".
- (b) Select "Display/change item by Function".
- (c) Select "Volume and Energy Items".
- (d) Change the value of any item on this screen that needs correction, documenting both the as-found and as-left values on the checklist.

### 6.8 *Verification of Successful Upgrade*

#### 6.8.1 Read item file

- (a) Select "Transfer", then select "Read Item File".
- (b) Enter serial number of instrument followed by the letter "A" as filename to download.
- (c) If prompted "Do you want to replace item file", select "Yes".
- (d) Wait until transfer is complete, then select "Exit".

#### 6.8.2 View item file

- (a) Select "Reports".
- (b) Select "Item Reports".
- (c) Select filename downloaded in step 6.8.1 (or type it in) then select "OK".
- (d) Verify that the following items were updated correctly and record the associated values on the form identified in clause 7.2:
  - (i) Corrected volume (item 0).
  - (ii) Uncorrected volume (item 2).
  - (iii) Firmware version (item 122), [should now read 5.23]
  - (iv) Pressure (item 8).

- (v) Temperature (item 26).
  - (vi) Instrument serial number (item 62).
  - (vii) Total correction factor (item 43).
  - (viii) Supercompressibility factor (item 47).
  - (ix) Specific gravity (item 53).
  - (x) % N2 for supercompressibility (item 54).
  - (xi) % CO2 for supercompressibility (item 55).
  - (xii) Local atmospheric pressure (item 14), [for gauge transducers only].
  - (xiii) Memory battery voltage (item 51).
- (e) If a pulse output board is installed on the EC-AT, verify that the following additional items were updated correctly and record the associated values on the form identified in clause 7.2:
- (i) Pulse Output A Scaling Factor (item 56).
  - (ii) Pulse Output B Scaling Factor (item 57).
  - (iii) Pulse Output C Scaling Factor (item 58).

## 6.9 *Instrument Recommissioning*

### 6.9.1 Lock the event logger

Note: Event loggers must be locked in order to meet Measurement Canada requirements. Locking the event logger must be done through the instrument's keypad. In order to lock the event logger:

- (a) Press the "MI" button.
- (b) Press "11111" and then "ENTR".
- (c) When the lower LCD displays "EVENTLOG USER ID", press "YES".
- (d) When the lower LCD displays "SELECT FUNCTION", press "DISP" and then enter "149".
- (e) When the lower LCD displays "EVENT LOCK" and the upper screen displays "0", press "CHNG" and then "0".
- (f) When the lower LCD displays "PERMANENT LOCK", press "YES".
- (g) When the lower LCD displays "Cannot Undo" and then after a couple of seconds displays "CONTINUE?", press "YES".
- (h) When the lower LCD displays "ARE YOU SURE?", press "YES". (Note: The lower LCD will now display "PERMANENT LOCK" indicating that the event logger is locked.)
- (i) Press "EXIT" twice to return the unit to the Corrector mode.

### 6.9.2 Return instrument to service

- (a) Exit the AT-Link software program and disconnect the I/O cable from the instrument.
- (b) Install the protective aluminum plate over the main circuit board.
- (c) Plug in the index switch cable.
- (d) Close instrument door and latch.
- (e) Resecure instrument to prevent unauthorized access.

## 6.10 *Documentation Completion*

6.10.1 Make a back-up copy of all computer files created during the firmware upgrade process on a diskette or the computer's hard disk.

6.10.2 Review the information captured on the forms and complete where necessary.



**7. Documentation**

7.1 Appendix G. Firmware Upgrade Procedure Checklist

7.2 Appendix H. Firmware Upgrade Measurement Data Form

7.3 Appendix I. Mercury Instruments EC-AT Register Item Codes and Descriptions

## Technical Procedure 4

### Firmware Upgrade of Mercury Instruments EC-AT Electronic Volume Conversion Device

(Version 4.xx to Version 5.23)

#### Contents

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  - 6.9 *Instrument Recommissioning*
  - 6.10 *Documentation Completion*
7. Documentation

## 1. Purpose

The purpose of this procedure is to provide instruction for upgrading the firmware of a Mercury Instruments EC-AT electronic volume conversion device to firmware version 5.23.

## 2. Scope

This procedure applies to Mercury Instruments EC-AT devices which are programmed with version 4.xx firmware.

## 3. Reference

- 3.1 Mercury Instruments EC-AT Operations Manual.
- 3.2 Mercury Instruments AT Link for Windows software manual (electronic version).

## 4. Definitions

- 4.1 DCU: Data Control Unit.
- 4.2 PROM: Programmable read-only memory.

## 5. Apparatus

The following equipment is required to perform the firmware upgrade:

- (a) Laptop computer with a minimum of an 80486 processor and 8 MB of RAM, using a Windows operating system (Windows 3.1, 95, or NT). Note that 16 MB of RAM is required if Windows 95 or NT operating systems are used.
- (b) Mercury Instruments EC-AT version 5.23 firmware PROMs.
- (c) Mercury Instruments AT Link for Windows software, version 5.25 or higher.
- (d) PROM chip puller.
- (e) Mercury Instruments I/O cable, part number 40-1629.
- (f) Diskette for data storage.
- (g) Mercury Instruments EC-AT replacement memory battery.

## 6. Procedure

Document the successful completion of each of the procedural steps below including any relevant comments on the form identified in clause 7.1.

### 6.1 *Measurement Data Capture*

#### 6.1.1 Review instrument measurement features

- (a) Familiarize yourself with the features and operations of the EC-AT instrument by reviewing the manual referred to in clause 3.1.
- (b) Note procedure to access stored measurement data from the device's keypad, which is as follows:
  - (i) Press the "MI" button.
  - (ii) Enter the access code "11111" (five 1's), and then press "ENTR".
  - (iii) When the lower displays "Select Function", press the "DISP" button.

- (iv) Enter the item number followed by a press of the "ENTR" button to display the measurement data for that item.
- (v) If data for another item is required, repeat step (iv).
- (vi) Press the "EXIT" button twice to return the device to Corrector mode.

#### 6.1.2 Read and record critical measurement data

Using the steps in clause 6.1.1(b), access the following measurement data according to its item number and record the values on the form identified in clause 7.2:

- (a) Corrected volume (item 0).
- (b) Uncorrected volume (item 2).
- (c) Firmware version (item 122).
- (d) Pressure (item 8).
- (e) Temperature (item 26).
- (f) Instrument serial number (item 62).
- (g) Total correction factor (item 43).
- (h) Squared supercompressibility factor (item 116).
- (i) Specific gravity (item 53).
- (j) % N2 for supercompressibility (item 54).
- (k) % CO2 for supercompressibility (item 55).
- (l) Local atmospheric pressure (item 14), [for gauge transducers only].
- (m) Main battery voltage (item 48).
- (n) Memory battery voltage (item 51).

#### 6.1.3 Read and record optional measurement data

For devices equipped with a pulse output board, access the following additional items of measurement data and record the values on the form identified in clause 7.2:

- (a) Pulse Output A Scaling Factor (item 56).
- (b) Pulse Output B Scaling Factor (item 57).
- (c) Pulse Output C Scaling Factor (item 58).

### 6.2 *Preparation and Set-up*

#### 6.2.1 Prepare computer for use

- (a) Install the AT-Link for Windows software on the computer to be used and verify its functionality.
- (b) Familiarize yourself with the software's operation by reviewing the manual referred to in clause 3.2.
- (c) Verify that the computer's internal date and time are accurate; correct as necessary through operating system commands.
- (d) Connect the computer's COM port to the RS-232 serial port on back of EC-AT device using the I/O cable referred to in clause 5(e).

#### 6.2.2 Verify transducer serial number

- (a) Verify that the transducer serial number on the label of upper chip matches the serial number on transducer label. (Note: The transducer is located in the lower left corner of instrument case.)
- (b) If a list of instrument serial numbers is provided by Mercury Instruments, locate the transducer serial number on list and mark it as verified.

### 6.2.3 Verify firmware version is 4.xx

- (a) Open the instrument door and swing open the keypad assembly.
- (b) Remove the aluminum plate covering the main circuit board.
- (c) Locate the firmware chip which is the lower of the two IC PROM chips near the upper left-hand corner of the main circuit board (with white adhesive labels) and record the version number printed on the label.
- (d) If the firmware version is not on the PROM label, it can be identified through Item 122 in the instrument's Item list by performing the following steps:
  - (i) Access instrument through the keypad by pressing "MI".
  - (ii) Enter the access code "11111" (five 1's), and then press "ENTR".
  - (iii) Press "DISP", then access Item #122 by pressing "122" followed by "ENTR". The top LCD will display "4.xx", and lower LCD will display "FIRMWARE".
  - (iv) Press "EXIT" twice to return to Corrector Mode.

## 6.3 *Instrument Data Download*

Note: The steps under this heading save the instrument's Item code configuration, Item authorization, and audit trail information. The resulting files are used later to reconfigure the upgraded instrument.

### 6.3.1 Read item file

- (a) From the AT-Link software main menu, select "SETUP" and then select "SITE LIST".
- (b) Add the site location for the instrument to be converted. (Note: The site information and audit trail information will be placed in the AT-Link database.)
- (c) If not already present, set the "Site ID Number" register (item 200) to the instrument's serial number and the "Site ID Number Part 2" register (item 201) to the company's number for the instrument.
- (d) From the AT-Link software main menu, select "TRANSFER".
- (e) Select "READ ITEM FILE".
- (f) Name the Item file using the 7-digit instrument serial number then click on OK.

### 6.3.2 Read authorization table

- (a) From AT-Link software main menu, select "TRANSFER".
- (b) Select "READ AUTHORIZATION TABLE".
- (c) Name the file using the 7-digit instrument serial number then click on OK.

### 6.3.3 Read audit trail

- (a) From the AT-Link software main menu, select "TRANSFER".
- (b) Select "READ AUDIT TRAIL".
- (c) Under "NUMBER OF ITEMS", select "FULL 10 ITEM DOWNLOAD".
- (d) Under "DOWNLOAD TYPE", select "NUMBER OF DAYS."
- (e) Under "NUMBER OF DAYS", enter "999". Click on OK. (Note: At this point, the AT-Link software may be used to view or print the Item or Authorization Reports.)
- (f) Disconnect the serial link.

## 6.4 *Instrument Shutdown*

- 6.4.1 Record the instrument's mechanical index reading before proceeding with shutdown.

#### 6.4.2 Decommission instrument

- (a) **Important: *Unplug the index switch cable (white plug) from the input switch board. DO NOT plug index switch cable back in until that step is reached in clause 6.9.2.***
- (b) Access instrument through keypad, press "MI".
- (c) Enter access code "11111", press "ENTR".
- (d) At "SELECT FUNCTION", press "AUX" three times.
- (e) When the lower LCD displays "SHUTDOWN?", press "YES".
- (f) When the lower LCD displays "ARE YOU SURE?", press "YES".
- (g) Unplug the main battery cable.

#### 6.4.3 Remove the memory battery from main circuit board

- (a) Remove the memory battery from the upper left corner of the main circuit board, using the PROM puller if necessary.
- (b) Remove silicone RTV if still present on memory battery.

### 6.5 *Firmware Replacement*

#### 6.5.1 Remove both PROM chips from their sockets

Note: The upper chip is the "Char" PROM and contains transducer characterization information; the lower chip is the "Firmware" PROM.

- (a) Using the PROM puller tool, carefully remove both PROM chips.
- (b) Place the PROM chips in a protective sleeve or case for return to the Measurement Supervisor.

#### 6.5.2 Install new firmware chips

- (a) Note that the PROM marked "2 UPPER" is to be installed in the upper socket and the PROM marked "1 LOWER" is to be installed in the lower socket.
- (b) Install both PROM chips with the notch positioned to the left (or outside edge), inserting one row of the chip's pins are in the appropriate socket, then tipping the chip until the other row of pins is in the socket.
- (c) If PROMs are difficult to insert into socket, slightly roll/bend pins together by pressing each side of the chip on a clean flat surface and repeat step (b).
- (d) Before continuing, double check both PROM chips for:
  - (i) Proper location.
  - (ii) Installation with notch to left.
  - (iii) All pins are in their socket holes and not bent under the body of the chip.

### 6.6 *Instrument Reconfiguration*

#### 6.6.1 Re-install instrument batteries

- (a) If the memory battery voltage recorded in step 6.1.2(m) is less than 3 V (dc), use the replacement memory battery and dispose of the old battery.
- (b) Use the white silk-screen outline as guide for proper battery orientation while installing. (Note: It may be necessary to bend the battery leads slightly to create a snug fit.)
- (c) Except for the Index Switch Input Cable, make sure all cable connectors are properly seated.
- (d) Plug in the memory battery.
- (e) Plug in the main battery.

## 6.6.2 Configure instrument with factory default settings

- (a) Press the "MI" button on instrument keypad.
- (b) Check that the lower LCD displays "UNCONFIGURED".
- (c) If the lower LCD does not display "UNCONFIGURED", unplug the main battery and memory battery for 1 minute and start again at step 6.6.1.
- (d) Enter access code "21111" (top LCD will display five dashes "- - - - -") and press "ENTR".
- (e) When the lower LCD displays "SELF TEST?", press "YES".
- (f) When the lower LCD displays "ARE YOU SURE?", press "YES".
- (g) Verify that lower LCD displays says "SELF TEST OK".
- (h) If unit times out (i.e., both LCDs go blank), repeat the above steps starting at step (a) until successful.
- (i) If the instrument does not display "SELF TEST" within a short period of time (approximately 1 or 2 minutes maximum) or stays on "---TESTING---" for an unreasonably long period of time, check to make sure the PROM pins are inserted properly, otherwise continue with step (j).
- (j) Verify that the top LCD displays "22222" and lower LCD displays "CNFG ACCESS CODE" after briefly displaying "---TESTING---", then press "YES".
- (k) Verify that the top LCD displays "11111" and lower LCD displays "CAL ACCESS CODE", then press "YES".
- (l) Verify that the top LCD displays "0" and lower LCD displays "EVENTLOG USER ID", then press "YES".
- (m) Press "EXIT" twice to return the instrument to Corrector mode. (Note: The instrument should now display eight zeros (00000000) in the upper display and the lower display should be completely clear.)

## 6.7 *Instrument Data Upload and Updating*

### 6.7.1 Upload calibration and non-calibration item files

- (a) Ensure that the serial I/O cable is connected between the communications ports of the instrument and the laptop computer.
- (b) From the AT-Link software's main menu, choose "Transfer".
- (c) Select "Send Cal Items".
- (d) When prompted "Are You Sure You Want To Send Cal Items To The Instrument?", select "Yes".
- (e) Highlight the correct transducer number from the list and select OK.
- (f) Wait until transfer is complete, the green progress bar will be completely filled in.
- (g) Select "Exit".
- (h) From the AT-Link software's main menu, choose "Transfer".
- (i) Select "Send Non-Cal Items".
- (j) When prompted "Are You Sure You Want To Send Non Cal Items To The Instrument ?", select "Yes".
- (k) When prompted "Select An Item File to Send Non Calibration Items", select the ".itm" file with the matching instrument serial number.
- (l) Wait until transfer is complete, the green progress bar will be completely filled in.
- (m) Select "Exit".
- (n) From the AT-Link software's main menu, choose "Transfer".
- (o) Select "Send Authorization Table".
- (p) When prompted "Are You Sure You Want To Send An Authorization Table To The Instrument ?", select "Yes".
- (q) When prompted "Select A File to Send Authorization Table Items", select the ".ath" file with the matching instrument serial number.
- (r) Wait until transfer is complete, the green progress bar will be completely filled in.

- (s) Select "Exit".

#### 6.7.2 Verify firmware version and battery voltages

- (a) Press "MI", then enter Calibration Access Code "11111" followed by "ENTR".
- (b) When the lower display reads "EVENTLOG USER ID" and the upper display reads "0", press "YES".
- (c) When the lower display reads "SELECT FUNCTION", press "DISP" (the 1 button).
- (d) Enter item code "122" (Firmware version), and press "ENTR".
- (e) Verify that the lower display indicates "FIRMWARE", while the upper display indicates "5.23".
- (f) Enter item code "48" (Battery voltage), and press "ENTR".
- (g) Verify that the lower display indicates "BATTERY VOLTAGE", while the upper display indicates a value in the range 6.5 +/- 0.4 volts for the lithium battery pack, or 7.5 +/- 1.5 volts for alkaline battery pack.
- (h) Enter item code "51" (Memory battery voltage), and press "ENTR".
- (i) Verify that the lower display indicates "MEM BATT VOLTAGE", while the upper display indicates a value in the range 3.6 +/- 0.3 volts.

#### 6.7.3 Verify the instrument's date and time

- (a) From the AT-Link software main menu, select "DISPLAY/CHANGE ITEMS BY FUNCTION".
- (b) Select "AUDIT TRAIL CONFIGURATION ITEMS."
- (c) Select Item 203 "TIME".
- (d) If the displayed time is incorrect, click on "CHANGE" and enter the correct time.
- (e) Click on "WRITE" to update the instrument's setting.
- (f) Select Item 204 "DATE".
- (g) If the displayed date is incorrect, click on "CHANGE" and enter the correct date in MM/DD/YY format.
- (h) Click on "WRITE" to update the instrument's setting.

#### 6.7.4 Verify corrected and uncorrected volume values

- (a) From the AT-Link software main menu, choose "Display".
- (b) Select "Display/change item by Function".
- (c) Select "Volume and Energy Items".
- (d) Change the value of any item on this screen that needs correction, documenting both the as-found and as-left values on the checklist.

### 6.8 *Verification of Successful Upgrade*

#### 6.8.1 Read item file

- (a) Select "Transfer", then select "Read Item File".
- (b) Enter serial number of instrument followed by the letter "A" as filename to download.
- (c) If prompted "Do you want to replace item file", select "Yes".
- (d) Wait until transfer is complete, then select "Exit".

#### 6.8.2 View item file

- (a) Select "Reports".
- (b) Select "Item Reports".
- (c) Select filename downloaded in step 6.8.1 (or type it in) then select "OK".



- (d) Verify that the following items were updated correctly and record the associated values on the form identified in clause 7.2:
- (i) Corrected volume (item 0).
  - (ii) Uncorrected volume (item 2).
  - (iii) Firmware version (item 122), [should now read 5.23]
  - (iv) Pressure (item 8).
  - (v) Temperature (item 26).
  - (vi) Instrument serial number (item 62).
  - (vii) Total correction factor (item 43).
  - (viii) Supercompressibility factor (item 47).
  - (ix) Specific gravity (item 53).
  - (x) % N2 for supercompressibility (item 54).
  - (xi) % CO2 for supercompressibility (item 55).
  - (xii) Local atmospheric pressure (item 14), [for gauge transducers only].
  - (xiii) Memory battery voltage (item 51).
- (e) If a pulse output board is installed on the EC-AT, verify that the following additional items were updated correctly and record the associated values on the form identified in clause 7.2:
- (i) Pulse Output A Scaling Factor (item 56).
  - (ii) Pulse Output B Scaling Factor (item 57).
  - (iii) Pulse Output C Scaling Factor (item 58).

## 6.9 *Instrument Recommissioning*

### 6.9.1 Lock the event logger

Note: Event loggers must be locked in order to meet Measurement Canada requirements. Locking the event logger must be done through the instrument's keypad. In order to lock the event logger:

- (a) Press the "MI" button.
- (b) Press "11111" and then "ENTR".
- (c) When the lower LCD displays "EVENTLOG USER ID", press "YES".
- (d) When the lower LCD displays "SELECT FUNCTION", press "DISP" and then enter "149".
- (e) When the lower LCD displays "EVENT LOCK" and the upper screen displays "0", press "CHNG" and then "0".
- (f) When the lower LCD displays "PERMANENT LOCK", press "YES".
- (g) When the lower LCD displays "Cannot Undo" and then after a couple of seconds displays "CONTINUE?", press "YES".
- (h) When the lower LCD displays "ARE YOU SURE?", press "YES". (Note: The lower LCD will now display "PERMANENT LOCK" indicating that the event logger is locked.)
- (i) Press "EXIT" twice to return the unit to the Corrector mode.

### 6.9.2 Return instrument to service

- (a) Exit the AT-Link software program and disconnect the I/O cable from the instrument.
- (b) Install the protective aluminum plate over the main circuit board.
- (c) Verify that the cables at the bottom of the case are properly located and cannot come close to the rotating volume input shaft.
- (d) Plug the cable back into the Index Switch Input board.
- (e) Recheck the instrument's displayed values for corrected volume (Item 0) and uncorrected volume (Item 2) for correctness.
- (f) Resecure instrument to prevent unauthorized access.

**6.10 *Documentation Completion***

6.10.1 Make a back-up copy of all computer files created during the firmware upgrade process on a diskette or the computer's hard disk.

6.10.2 Review the information captured on the forms and complete where necessary.

**7. *Documentation***

7.1 Appendix G. Firmware Upgrade Procedure Checklist

7.2 Appendix H. Firmware Upgrade Measurement Data Form

7.3 Appendix I. Mercury Instruments EC-AT Register Item Codes and Descriptions

APPENDICES

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- A. Nonconformance / Corrective Action Report
- B. Personnel Training and Technician Qualifications Form
- C. Pressure and Temperature Standard Calibration Form
- D. Summary of Conversion Device Specification Requirements
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- H. Firmware Upgrade Measurement Data Form
- I. Mercury Instruments EC-AT Register Item Codes and Descriptions

**Appendix A. Nonconformance / Corrective Action Report**

|  |                  |
|--|------------------|
| Report #:  |                  |
| Nonconformance discovered during:    Inspection    Review    Audit    Other _____        |                  |
| Quality Program Manual Reference:  |                  |
| <b>Details of Nonconformance and Disposition</b>   |                  |
|  |                  |
| Signed by:   | Date:            |
| <b>Corrective Action</b>   |                  |
| Action to be taken to correct nonconformance and to prevent recurrence:                  |                  |
|  |                  |
| Signed by:   | Position/Title:  |
| Target Date:   | Completion date: |
| <b>Verification of the Corrective Action</b> (to be completed by Measurement Supervisor) |                  |
| Acceptance of the corrective action / comments:  |                  |
|  |                  |
| Signed by:   | Date:            |

**Appendix B. Personnel Training and Technician Qualifications Form**

| <b>MANAGEMENT TRAINING</b>                    |   |                         |
|---|---|-------------------------|
| <b>Name and Title</b>                         | <b>Nature of Training</b>   | <b>Date Completed</b>   |
| _____, Manager                                | Quality Program Familiarization   |                         |
| _____, Supervisor                             | Quality Program Scope and Responsibilities Review   |                         |
| <b>TECHNICIAN QUALIFICATIONS AND TRAINING</b> |   |                         |
| <b>Name, Title, Qualifications</b>            | <b>Nature of Training</b>   | <b>Date Completed</b>   |
|   | Quality Program Documentation Review<br>Technical Procedures and Elements Review<br>Hands-on Upgrading/Testing Demonstration<br>Test of Ability and Comprehension | _____<br>_____<br>_____ |
|   | Quality Program Documentation Review<br>Technical Procedures and Elements Review<br>Hands-on Upgrading/Testing Demonstration<br>Test of Ability and Comprehension | _____<br>_____<br>_____ |
|   | Quality Program Documentation Review<br>Technical Procedures and Elements Review<br>Hands-on Upgrading/Testing Demonstration<br>Test of Ability and Comprehension | _____<br>_____<br>_____ |

**Appendix C. Pressure and Temperature Standard Calibration Form**

| <b>Pressure Standard Calibration Record</b>    |                    |      |     |                      |      |     |                       |
|--|--------------------|------|-----|----------------------|------|-----|-----------------------|
| Working Std (WS) #                             |                    |      |     | Reference Std (RS) # |      |     |                       |
| Nominal Value                                  | WS Indicated Value |      |     | RS True Value        |      |     | WS Error<br>(WS - RS) |
|  | Up                 | Down | Avg | Up                   | Down | Avg |                       |
|  |                    |      |     |                      |      |     |                       |
|  |                    |      |     |                      |      |     |                       |
|  |                    |      |     |                      |      |     |                       |
|  |                    |      |     |                      |      |     |                       |
| Calibrated by:                                 |                    |      |     | Date:                |      |     |                       |
| Comments                                       |                    |      |     |                      |      |     |                       |
| <b>Temperature Standard Calibration Record</b> |                    |      |     |                      |      |     |                       |
| Working Std (WS) #                             |                    |      |     | Reference Std (RS) # |      |     |                       |
| Nominal Value                                  | WS Indicated Value |      |     | RS True Value        |      |     | WS Error<br>(WS - RS) |
|  |                    |      |     |                      |      |     |                       |
|  |                    |      |     |                      |      |     |                       |
|  |                    |      |     |                      |      |     |                       |
| Calibrated by:                                 |                    |      |     | Date:                |      |     |                       |
| Comments                                       |                    |      |     |                      |      |     |                       |

**Appendix D. Summary of Conversion Device Specification Requirements**

**Quality Characteristics and Associated Verification/Reverification Requirements**

| <b>Quality Characteristic</b>   | <b>Requirement</b>  |
|---|---|
| Device design and configuration   | identical to approved pattern   |
| Workmanship   | no defects which could affect device reliability permitted  |
| Markings  | unique inspection number, device design parameters, user-configurable parameters  |
| Electronic display  | all segments functioning  |
| Mechanical register   | all pointers or drums properly aligned  |
| Atmospheric pressure  | absolute error not to exceed $\pm[0.090 + (0.001 P_g)]$ psi where $P_g$ is minimum expected gauge pressure              |
| Programmed gas parameters   | representative of gas at actual or intended operational local within tolerances permitted by authorized procedure       |
| Pressure conversion   | relative error of device $P_m$ not to exceed $\pm 1.0\%$ over calibrated operating range                                |
| Temperature conversion  | relative error of device $T_m$ not to exceed $\pm 1.0\%$ over calibrated operating range                                |
| Supercompressibility correction   | relative error of $S_m$ not to exceed $\pm 0.3\%$ over calibrated operating range                                       |
| Volume conversion   | relative error of product of device $P_m$ , $T_m$ , and $S_m$ not to exceed $\pm 1.6\%$ over calibrated operating range |
| Ratio of volumetric input to unconverted volume registration              | no error permitted  |
| Ratio of converted volume registration to unconverted volume registration | no error permitted  |

**Appendix E. Conversion Device Test Set-up Diagram**

To be developed and supplied by applicant wishing to implement a Quality Program

**Appendix F. EC-AT Device Inspection Form**

|   |   |  |                 |
|---|---|--|-----------------|
| Inspection Date:                            |   | Test Location:                           |                 |
| Standard #:                                 |   | Inspected by:                            |                 |
| Manufacturer:                               |   | Model / Approval #:                      |                 |
| Inspection #:                               |   | Serial #:                                |                 |
| Base temperature: 15°C 60°F                 |   | Base pressure:                           |                 |
| Atmospheric pressure (item 14):             |   | Pressure range:                          |                 |
| Volume per input revolution:                |   | Firmware version (item 122):             |                 |
| Main battery voltage (item 48):             |   | Memory battery voltage (item 51):        |                 |
| Corrected volume (item 0):                  |   | Uncorrected volume (item 2):             |                 |
| Pressure (item 8):                          |   | Temperature (item 26):                   |                 |
| Carbon dioxide value (item 55):             |   | Nitrogen value (item 54):                |                 |
| Relative density value (item 54):           |   | Total correction factor (item 43):       |                 |
| Pressure correction factor (item 44):       |   | Temperature correction factor (item 45): |                 |
| Supercompressibility multiplier (item 116): |   |  |                 |
| <b>Visual Examination</b> (reference 6.3)   |   | <b>Status</b>                            | <b>Comments</b> |
| (a)   | Examine device for conformity with MC approval and use requirements |  |                 |
| (b)   | Examine device for MC verification                                  |  |                 |
| (c)   | Examine device for defects  |  |                 |
| (d)   | Examine electronic display for defects                              |  |                 |
| (e)   | Examine mechanical register for defects                             |  |                 |



Appendix F. EC-AT Device Inspection Form (continued)

| Performance Evaluation (reference 6.4 to 6.8) |                                 |                           |            |           |
|---|---------------------------------|---------------------------|------------|-----------|
| Item #  | Description                     | Value Displayed by Device | True Value | Error (%) |
| 8   | Pressure                        |                           |            | xxxxx     |
| 14  | Local atmospheric pressure      |                           | xxxxx      | xxxxx     |
| 13  | Base pressure                   |                           | xxxxx      | xxxxx     |
| 44  | Pressure multiplier             |                           |            |           |
|   |                                 |                           |            |           |
| 26  | Temperature                     |                           |            | xxxxx     |
| 34  | Base temperature                |                           | xxxxx      | xxxxx     |
| 45  | Temperature multiplier          |                           |            |           |
|   |                                 |                           |            |           |
| 116   | Supercompressibility multiplier |                           |            |           |
| 53  | Specific gravity                |                           | xxxxx      | xxxxx     |
| 54  | % N2 for supercompressibility   |                           | xxxxx      | xxxxx     |
| 55  | % CO2 for supercompressibility  |                           | xxxxx      | xxxxx     |
| 43  | Total correction factor         |                           |            |           |
|   |                                 |                           |            |           |
|   | Gas flow status                 |                           | xxxxx      | xxxxx     |
| <b>Observations:</b>                          |                                 |                           |            |           |
| -----   |                                 |                           |            |           |
| -----   |                                 |                           |            |           |
| -----   |                                 |                           |            |           |
| -----   |                                 |                           |            |           |
| -----   |                                 |                           |            |           |
| -----   |                                 |                           |            |           |
| -----   |                                 |                           |            |           |
| -----   |                                 |                           |            |           |
| -----   |                                 |                           |            |           |
| -----   |                                 |                           |            |           |

**Appendix G. Firmware Upgrade Procedure Checklist**

| Device #:   |  | Date:  | Performed by: |  |
|---|--|--------|---------------|--|
| Clause  | Description                                | Status | Comments      |  |
| <b>6.1 Measurement Data Capture</b>                               |  |        |               |  |
| 6.1.1   | Review instrument measurement features     |        |               |  |
| 6.1.2   | Read & record critical measurement data    |        |               |  |
| 6.1.3   | Read & record optional measurement data    |        |               |  |
| <b>6.2 Preparation and Set-up</b>                                 |  |        |               |  |
| 6.2.1   | Prepare computer for use                   |        |               |  |
| 6.2.2   | Verify transducer serial number            |        |               |  |
| 6.2.3   | Verify firmware version is 3.10 (or 4.xx)  |        |               |  |
| <b>6.3 * Instrument Data Download (Version 3.10 devices only)</b> |  |        |               |  |
| 6.3.1   | Configure DCU report format                |        |               |  |
| 6.3.2   | Download instrument data                   |        |               |  |
| <b>6.3 * Instrument Data Download (Version 4.xx devices only)</b> |  |        |               |  |
| 6.3.1   | Read item file                             |        |               |  |
| 6.3.2   | Read authorization table                   |        |               |  |
| 6.3.3   | Read audit trail                           |        |               |  |
| <b>6.4 Instrument Shutdown</b>                                    |  |        |               |  |
| 6.4.1   | Record mechanical index reading            |        |               |  |
| 6.4.2   | Decommission instrument                    |        |               |  |
| 6.4.3   | Remove memory battery                      |        |               |  |
| <b>6.5 Firmware Replacement</b>                                   |  |        |               |  |
| 6.5.1   | Remove both PROM chips                     |        |               |  |
| 6.5.2   | Install new firmware chips                 |        |               |  |
| <b>6.6 Instrument Reconfiguration</b>                             |  |        |               |  |
| 6.6.1   | Re-install batteries                       |        |               |  |
| 6.6.2   | Configure instrument with factory settings |        |               |  |

**Appendix G. Firmware Upgrade Procedure Checklist (continued)**

| Clause       | Description                                     | Status | Comments                           |
|--------------|---|--------|------------------------------------|
| <b>6.7 *</b> | <b>Instrument Data Upload and Updating</b>      |        | <b>(Version 3.10 devices only)</b> |
| 6.7.1        | Upload calibration & non-calibration item files |        |                                    |
| 6.7.2        | Verify the instrument's date and time           |        |                                    |
| 6.7.3        | Verify corrected & uncorrected volume values    |        |                                    |
| <b>6.7 *</b> | <b>Instrument Data Upload and Updating</b>      |        | <b>(Version 4.xx devices only)</b> |
| 6.7.1        | Upload calibration & non-calibration item files |        |                                    |
| 6.7.2        | Verify firmware version & battery voltages      |        |                                    |
| 6.7.3        | Verify the instrument's date and time           |        |                                    |
| 6.7.4        | Verify corrected & uncorrected volume values    |        |                                    |
| <b>6.8</b>   | <b>Verification of Successful Upgrade</b>       |        |                                    |
| 6.8.1        | Read item file                                  |        |                                    |
| 6.8.2        | View item file                                  |        |                                    |
| <b>6.9</b>   | <b>Instrument Recommissioning</b>               |        |                                    |
| 6.9.1        | Lock the event logger                           |        |                                    |
| 6.9.2        | Return instrument to service                    |        |                                    |
| <b>6.10</b>  | <b>Documentation Completion</b>                 |        |                                    |
| 6.10.1       | Back-up all upgrade-related computer files      |        |                                    |
| 6.10.2       | Review information on forms for completeness    |        |                                    |

**Appendix H. Firmware Upgrade Measurement Data Form**

| Device #: |                                 | Date:                        | Performed by:               |  |
|-----------|---------------------------------|------------------------------|-----------------------------|--|
| Item #    | Description                     | As-Found Value<br>(ref. 6.1) | As-Left Value<br>(ref. 6.8) |  |
| 0         | Corrected volume                |                              |                             |  |
| 2         | Uncorrected volume              |                              |                             |  |
| 122       | Firmware version                |                              |                             |  |
| 8         | Pressure                        |                              |                             |  |
| 26        | Temperature                     |                              |                             |  |
| 62        | Instrument serial number        |                              |                             |  |
| 43        | Total correction factor         |                              |                             |  |
| 116       | Supercompressibility multiplier |                              |                             |  |
| 53        | Specific gravity                |                              |                             |  |
| 54        | % N2 for supercompressibility   |                              |                             |  |
| 55        | % CO2 for supercompressibility  |                              |                             |  |
| 14        | Local atmospheric pressure      |                              |                             |  |
| 56        | Pulse Output A Scaling Factor   |                              |                             |  |
| 57        | Pulse Output B Scaling Factor   |                              |                             |  |
| 58        | Pulse Output C Scaling Factor   |                              |                             |  |
| 48        | Main battery voltage            |                              |                             |  |
| 51        | Memory battery voltage          |                              |                             |  |

Appendix I. Mercury Instruments EC-AT Register Item Codes and Descriptions

| Code and Description        | Code and Description        | Code and Description        |
|-----------------------------|-----------------------------|-----------------------------|
| 000 Corrected Volume        | 048 Battery Voltage Reading | 096 Corr Vol Display Res    |
| 001 Press Cor Volume        | 049 Batt Low Volt Limit     | 097 Uncorr Vol Display Res  |
| 002 Uncorrected Volume      | 050 Shutdown Voltage Limit  | 098 Meter Index Rate        |
| 003 Cor Vol @ LO Press      | 051 Memory Battery Voltage  | 099 Battery Low Volt Alarm  |
| 004 Cor Vol @ HI Temp       | 052 Mem Batt LO Volt Limit  | 100 Battery Cycles Alarm    |
| 005 Pulser 'A' # of Pulses  | 053 Specific Gravity For Sp | 101 Memory Battery Low      |
| 006 Pulser 'B' # of Pulses  | 054 % N2 For Supercompress  | 102 Index SW#1 Fault Alarm  |
| 007 Pulser 'C' # of Pulses  | 055 % CO2 For Supercompress | 103 Index SW#2 Fault Alarm  |
| 008 Gas Pressure            | 056 Pulser 'A' Out Scaling  | 104 A/D Fault Alarm         |
| 009 Gas Pressure Maximum    | 057 Pulser 'B' Out Scaling  | 105 Press Out Of Range Alm  |
| 010 Press High Alm Limit    | 058 Pulser 'C' Out Scaling  | 106 Temp Out Of Range Alarm |
| 011 Press Low Alm Limit     | 059 Battery Wakeup Cycles   | 107 Tamper Detected         |
| 012 Atmospheric Cal Ref     | 060 Battery Cycles Limit    | 108 Alarm Output            |
| 013 Base Pressure           | 061 Display Test            | 109 Fixed Pressure Factor   |
| 014 Atmospheric Pressure    | 062 Corrector Serial Number | 110 Fixed Super Factor      |
| 015 Reference Press #1      | 063 Gas Pressure Minimum    | 111 Fixed Temp Factor       |
| 016 Reference Press #2      | 064 Gas Temperature Maximum | 112 Transducer Type         |
| 017 Press Calibration Zero  | 065 Gas Temperature Minimum | 113 High Resolution Cor Vol |
| 018 1 Prev Press Cal Zero   | 066 Pulser 'A' Output Limit | 114 Meter Scaling           |
| 019 2 Prev Press Cal Zero   | 067 Pulser 'B' Output Limit | 115 Pulser Output Time      |
| 020 Press Calibration Span  | 068 Pulser 'C' Output Limit | 116 Squared Supercompress   |
| 021 1 Prev Press Cal Span   | 069 Pulser 'A' Limit Alarm  | 117 Tag Number              |
| 022 2 Prev Press Cal Span   | 070 Pulser 'B' Limit Alarm  | 118 Reference Number 1      |
| 023 Min PCal Point Diff %   | 071 Pulser 'C' Limit Alarm  | 119 Reference Number 2      |
| 024 Excess PCal Change %    | 072 Alarm 1 Item #          | 120 Pressure Cal Date       |
| 025 Transducer Range        | 073 Alarm 2 Item #          | 121 Temperature Cal Date    |
| 026 Gas Temperature         | 074 Alarm 3 Item #          | 122 Firmware Version        |
| 027 Gas Temp Lo Alm Limit   | 075 Mag List 2 Item 1 #     | 123 Audit Trail Enable      |
| 028 Gas Temp Hi Alm Limit   | 076 Mag List 2 Item 2 #     | 124 Revolutions Per Wakeup  |
| 029 Reference Temp #1       | 077 Mag List 2 Item 3 #     | 125 Pulser Power Factor     |
| 030 Reference Temp #2       | 078 Mag List 2 Item 4 #     | 126 Instrument Baud Rate    |
| 031 Case Temperature        | 079 Mag List 2 Item 5 #     | 128 Mag Alarm Acknowledge   |
| 032 Case Temp Maximum       | 080 Mag List 2 Item 6 #     | 129 Live Display Enable     |
| 033 Case Temp Minimum       | 081 Mag List 2 Item 7 #     | 130 Mag List 1 Item 1 #     |
| 034 Base Temperature        | 082 Mag List 2 Item 8 #     | 131 Mag List 1 Item 2 #     |
| 035 Temperature Cal Zero    | 083 Mag List 2 Item 9 #     | 132 Mag List 1 Item 3 #     |
| 036 1 Prev Temp Cal Zero    | 084 Mag List 2 Item10 #     | 133 Mag List 1 Item 4 #     |
| 037 2 Prev Temp Cal Zero    | 085 Mag List 2 Item11 #     | 134 Mag List 1 Item 5 #     |
| 038 Temperature Cal Span    | 086 Mag List 2 Item12 #     | 135 Mag List 1 Item 6 #     |
| 039 1 Prev Temp Cal Span    | 087 Pressure Units          | 136 Item Number Enable      |
| 040 2 Prev Temp Cal Span    | 088 Pressure Display Res    | 137 Xducer Range            |
| 041 Min TCal Point Diff %   | 089 Temperature Units       | 138 Transducer Serial #     |
| 042 Excess TCal Change %    | 090 Corr Volume Units       | 139 Serial Link Config      |
| 043 Total Correction Factor | 091 Pressure Cor Vol Units  | 140 Energy                  |
| 044 Press Correction Factor | 092 Uncorr Volume Units     | 141 Energy Units            |
| 045 Temp Correction Factor  | 093 Pulser 'A' Out Select   | 142 Gas Energy Value        |
| 046 Aux Correction Factor   | 094 Pulser 'B' Out Select   | 143 Pressure Low Alarm      |
| 047 Unsquared Supercompress | 095 Pulser 'C' Out Select   | 144 Temperature Low Alarm   |

Appendix I. Mercury Instruments EC-AT Register Item Codes and Descriptions (continued)

| Code and Description        | Code and Description        | Code and Description        |
|-----------------------------|-----------------------------|-----------------------------|
| 145 Pressure High Alarm     | 211 Peak Hour Cor Vol       | 260 Selectble Report Item 3 |
| 146 Temperature High Alarm  | 212 Peak Hour End Time      | 261 Selectble Report Item 4 |
| 147 Supercompress Tbl Used  | 213 Peak Hour Date          | 262 Date Format             |
| 148 Incremental Energy      | 214 Interval HI Pressure    | 273 Maximum Flow Rate       |
| 149 Event Logger Lock       | 215 Interval LO Pressure    | 274 Maximum Flow Rate Time  |
| 163 Flow Rate High Alarm    | 216 Interval HI Temperature | 275 Maximum Flow Rate Date  |
| 164 Flow Rate High Limit    | 217 Interval LO Temp        | 276 Maximum Flow Rate Press |
| 165 RBX Alarm Enable        | 218 Inst Dial Rate          | 277 Maximum Hour Cor Vol    |
| 166 Pressure Dead Band      | 219 Peak Dial Rate          | 278 Maximum Hour End Time   |
| 167 Temperature Dead Band   | 220 Nominated Cor Vol       | 279 Maximum Hour Date       |
| 168 Battery Dead Band       | 221 Daily Cor Vol Alm Lmt   | 280 Max Hour Cor Vol Press  |
| 169 Rate Dead Band          | 222 Daily Cor Vol Alarm     | 281 Maximum Dial Rate       |
| 170 Protocol Code A         | 223 Daily Cor Vol           | 282 Maximum Dial Rate Time  |
| 171 Timeout Delay 1         | 224 Daily Unc Vol           | 283 Maximum Dial Rate Date  |
| 172 Timeout Delay 2         | 225 Incremental Cor Vol     | 284 Maximum Dial Rate Press |
| 173 Report Trigger 9(RESET) | 226 Incremental Unc Vol     | 285 Maximum Pressure        |
| 174 Report Trigger 10(CLR)  | 227 Report Format (DCU)     | 286 Maximum Pressure Time   |
| 175 Report Trigger 11(SHUT) | 228 Number of Days Reported | 287 Maximum Pressure Date   |
| 176 RBX Alarm Event         | 229 Optional Report Item 1  | 288 Max Press Flow Rate     |
| 177 Pulse Out Repetitions   | 230 Optional Report Item 2  | 289 Minimum Pressure        |
| 183 Previous Day Corvol     | 231 Optional Report Item 3  | 290 Minimum Pressure Time   |
| 184 Previous Day Uncvol     | 232 Optional Report Item 4  | 291 Minimum Pressure Date   |
| 185 Prev Day Avg Pressure   | 233 Optional Report Item 5  | 292 Min Press Flow Rate     |
| 186 Previous Day Avg Temp   | 234 Optional Report Item 6  | 293 Maximum Gas Temp        |
| 187 Avg Unsquared Super     | 235 Report Trigger 1 (TIME) | 294 Maximum Gas Temp Time   |
| 188 Daily Avg Unsq Super    | 236 Report Trigger 2 (VOL ) | 295 Maximum Gas Temp Date   |
| 189 Prev Day Avg Unsq Super | 237 Report Trigger 3 (ALRM) | 296 Max Gas Temp Flow Rate  |
| 190 Daily Energy            | 238 Report Trigger 4 (DCU ) | 297 Minimum Gas Temp        |
| 191 Previous Day Energy     | 239 Report Trigger 5 (MAG ) | 298 Minimum Gas Temp Time   |
| 192 Daily Peak Flow Rate    | 240 Report Trigger 6 (CAL ) | 299 Minimum Gas Temp Date   |
| 193 Daily Peak Flow Time    | 241 Report Trigger 7 (CONF) | 300 Min Gas Temp Flow Rate  |
| 194 Prev Day Pk Flow Rate   | 242 Report Trigger 8 (CHNG) | 301 P Comp Coefficient 1    |
| 195 Prev Day Pk Flow Time   | 243 Month Peak Hour Cor Vol | 302 P Comp Coefficient 2    |
| 196 Event Log User ID       | 244 Month Peak Hour Date    | 303 P Comp Coefficient 3    |
| 197 Max Dial Rate           | 245 Month Peak Hour Time    | 304 P Comp Coefficient 4    |
| 198 Max Flow Rate           | 246 Month Peak Day Cor Vol  | 305 P Comp Coefficient 5    |
| 199 Date DD-MM-YY           | 247 Month Peak Day Date     | 306 P Comp Coefficient 6    |
| 200 Site ID Number          | 248 Prev Mo Pk Hour Cor Vol | 307 P Comp Coefficient 7    |
| 201 Site ID Number Part 2   | 249 Prev Mo Pk Hour Date    | 308 P Comp Coefficient 8    |
| 202 Log Interval            | 250 Prev Mo Pk Hour Time    | 309 P Comp Coefficient 9    |
| 203 Time                    | 251 Prev Mo Pk Day Cor Vol  | 310 P Comp Coefficient 10   |
| 204 Date                    | 252 Prev Mo Pk Day Date     | 311 P Comp Coefficient 11   |
| 205 Start Time              | 253 Max Day Cor Vol         | 312 P Comp Coefficient 12   |
| 206 Average Pressure        | 254 Max Day Date            | 313 P Comp Coefficient 13   |
| 207 Average Temperature     | 256 Daily Average Pressure  | 314 P Comp Coefficient 14   |
| 208 Average Flow Rate       | 257 Daily Average Temp      | 315 P Comp Coefficient 15   |
| 209 Inst Flow Rate          | 258 Selectble Report Item 1 | 316 P Comp Coefficient 16   |
| 210 Peak Flow Rate          | 259 Selectble Report Item 2 | 317 P Comp Coefficient 17   |

**Appendix I. Mercury Instruments EC-AT Register Item Codes and Descriptions (continued)**

| Code and Description      | Code and Description      | Code and Description      |
|---------------------------|---------------------------|---------------------------|
| 318 P Comp Coefficient 18 | 323 P Comp Coefficient 23 | 328 P Comp Coefficient 28 |
| 319 P Comp Coefficient 19 | 324 P Comp Coefficient 24 | 329 P Comp Coefficient 29 |
| 320 P Comp Coefficient 20 | 325 P Comp Coefficient 25 | 330 P Comp Coefficient 30 |
| 321 P Comp Coefficient 21 | 326 P Comp Coefficient 26 | 331 P Comp Coefficient 31 |
| 322 P Comp Coefficient 22 | 327 P Comp Coefficient 27 | 332 P Comp Coefficient 32 |

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