

<b>BROOKHAVEN NATIONAL LABORATORY</b> Safety & Health Services Division	NUMBER <b>IH75530</b>
	REVISION <b>SHSD/FCR FINAL rev1</b>
<b>INDUSTRIAL HYGIENE GROUP</b> Standard Operating Procedure: Field Procedure	DATE <b>04-11-01</b>
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SUBJECT: INSTRUMENT OPERATION: <b>JEROME 431-X</b> <b>MERCURY VAPOR ANALYZER</b>	

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### **1.0 Purpose/Scope**

This procedure provides a standardized method for operation for the Jerome 431-X Gold Film Mercury Analyzer. It should be used in conjunction with the IH procedure IH75180: *Atmospheric Testing Using Direct Reading Instruments*.

The Jerome 431-X Gold Film Mercury Analyzer provides a method for easy and accurate analysis of elemental mercury vapor in the workplace environment and for determining the location of mercury spills with a range of 0.001 to 0.999 milligrams per cubic meter of mercury (mg/m<sup>3</sup> Hg).

### **2.0 Responsibilities**

- 2.1 Use of the Jerome 431-X Gold Film Mercury Analyzer shall be performed only by persons who have demonstrated the competence to satisfactorily use the meter as evidenced by experience and training to the satisfaction of their supervision.
- 2.2 Personnel that perform exposure monitoring with this instrument are responsible to follow all steps in this procedure.
- 2.3 The data collected using this meter must have an appropriate evaluation of the hazard and risk by a skilled Industrial Hygiene professional.

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### 3.0 Definitions

None.

### 4.0 Prerequisites

#### 4.1 Training prior to using this meter:

- 4.1.1 Demonstration of proper operation of the Jerome 431-X Gold Film Mercury Analyzer to the satisfaction of the employee's supervision.
- 4.1.2 HAZCOM or Lab Standard.
- 4.1.3 Other appropriate training for the area to be entered (check with ESH coordinator or FS Representative for the facility).

#### 4.2 Area Access:

- 4.2.1 Contact the appropriate Facility Support Representative or Technician to obtain approval to enter radiological areas.
- 4.2.2 Verify with the appropriate Facility Support Representative or Technician if a Work Permit or Radiological Permit is needed or is in effect. If so, review and sign the permit.

### 5.0 Precautions

#### 5.1 Hazard Determination:

- 5.1.1 The operation of this meter does not cause exposure to any chemical, physical, or radiological hazards. The meter design does not cause significant ergonomic concerns in routine use. The meter does not generate Hazardous Waste.
- 5.1.2 By its very nature as a mercury analyzer, this meter may be used in areas where elemental mercury is known or suspected to be present. Inhalation of mercury can have significant neurological health hazards including:
  - Acute inhalation of high airborne levels
  - Chronic (exposure over a long period- weeks to months) of low airborne levels.

The meter readings must be observed continuously when entering areas of potential mercury vapor exposure and the user should leave the area if the

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OSHA PEL or ACGIH TLV levels are exceeded. If the Jerome 431-X is to be used for measurements of mercury processes where exposure may vary significantly over time and the length of exposure will be several hours, employee exposure monitoring may be required using a sorbent tube or badge. These evaluation of exposure monitoring needs should be made by a cognizant ESH professional.

- 5.1.3 There may be significant chemical or radiological hazards in areas where this meter is used. These hazards must receive a hazard evaluation by a cognizant ESH professional.

## 5.2 Personal Protective Equipment

- 5.2.1 **Hand:** Contact with liquid elemental mercury must be prevented. Use of this meter in areas of known or suspected mercury contamination requires the use of disposable gloves. Exam-style, splash gloves are acceptable. Acceptable elastomers are: Nitrile, Neoprene, PVC, Butyl, Natural Rubber, Viton, and PEVAL (SilverShield®).

### 5.2.2 Body:

- 5.2.2.1 If contact of the body with mercury contaminated surfaces is anticipated, a disposable suit should be used. Acceptable CPC materials include: Tyvek®, KleenGuard®, and cotton. Disposable garments must be discarded as mercury waste if contact with contamination has occurred.
- 5.2.2.2 If contact with potentially contaminated surfaces is not expected, body covering are optional. However, if personal clothing items become contaminated, they must be surrender for BNL cleaning or disposal.

### 5.2.3 Foot:

- 5.2.3.1 If contact of the feet is anticipated with liquid mercury contamination, disposable shoe coverings, boots or booties should be used. Acceptable CPC material include: Tyvek®, KleenGuard®, and rubber.
- 5.2.3.2 If contact with potentially contaminated surfaces is not expected, shoe covering are optional. However, if personal shoes become contaminated, they must be surrender for BNL cleaning or disposal.

- 5.2.4 **Respiratory:** If mercury levels exceed the ACGIH TLV of 0.025 mg/m<sup>3</sup> (and OSHA standard of 0.1 mg/m<sup>3</sup>), respirators are required. A half face or full face APR or PAPR respirator with Mercury cartridge or an air line respirators may

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be used up to assigned protection factor listed in the BNL's Respiratory Protection Selection and Issuance SOPS.

5.2.5 **Eye:** Safety Glasses with side shields are required.

### 5.3 Instrument protection:

- 5.3.1 The Jerome 431-X is intended for elemental mercury vapor use only. DO NOT allow the probe or the instrument's intake to come in contact with liquids, dust or other foreign material.
- 5.3.2 Do not allow mercury contamination to stay on film overnight. Regenerate the sensor at the end of use. See Step 6.

## 6.0 Procedure

### 6.1 Equipment:

- Meter Body
- Sample Probe- aluminum, 0.25" O.D.
- Optional: remote sampling tubing- (not supplied with meter). Up to 25 feet of Teflon® tubing (0.25" O.D.) may be inserted into the probe fitting. Tygon® tubing may absorb mercury vapor and should not be used. Perform the Zero and Operational Check of the meter with the tubing in-line to determine the time delay in meter reading due to the transit of the sample vapor in the tubing.

### 6.2 Operation of the Jerome 431-X

- 6.2.1 **Set-up:** Place the metal Probe into the probe fitting attached to the front of the meter.
- 6.2.2 **Power On:** Plug the instrument into an AC power outlet. Press the power *ON* button: The digital meter displays **000**. *Disregard the digital meter's initial momentary reading.*
- 6.2.3 Recharge or replace the battery pack if the LO BAT indicator remains ON. The Jerome 431-X operates a minimum of 6 hours on a fully charged battery. A complete battery recharge takes 14 hours.
- 6.2.4 **Initial Warm Up:** Allow the instrument's electronics to stabilize by allowing 1 minute for the unit to warm up.
- 6.2.5 **Sensor Regeneration:** Regenerate the sensor (clear the sensors of any accumulated mercury) by following these steps. Plug the instrument into an

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AC power outlet. Press *REGEN* button. The instrument will begin a 10 minute regeneration cycle, indicated by *.H.H.H* flashing on the display. **Do not interrupt this cycle.**

- 6.2.6 **Zero:** Adjust the sensor by pressing the *ZERO* button and turning the zero adjust screw located under the handle. Adjust until the display reads 0.
- 6.2.7 **Bump Check:** Verifying that the Jerome 431-X is operating properly by sampling the headspace of a vial of mercury and observing the response. Do not use the meter if the instrument fails to detect mercury. Perform the bump test at least once each day of use.
- 6.2.8 **Taking a reading:** *The instrument is now ready to sample. Note that as the instrument measures mercury, the ZERO will display H. Do not adjust the ZERO after the instrument has measured mercury and before the next regeneration.*

**Note:** *For maximum accuracy, wait 30 minutes after the sensor regeneration cycle to rezero the unit. For emergency response, such as for spill cleanup, the unit can be rezeroed immediately after sensor regeneration.*

- 6.2.8.1 Press and hold the *SAMPLE* button and start taking the sample. When you are finished taking the sample, release the *SAMPLE* button.

*Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of Mercury. Each measurement should consist of a 15 minute sample or series of consecutive samples totaling 15 minutes in the employees breathing zone. A minimum of three measurements should be taken on one work shift and the highest of all measurements taken should be used to estimate the employee's exposure.*

*During the sample cycle, the digital meter displays a bar (-) which indicates the amount of sensor saturation. Note: The bar (or bars) flash after 2 second and again after an additional 7 seconds. This flashing signals the opening and closing of the solenoid sample bypass.*

- 6.2.8.2 At the end of the 12 second sample cycle, read the digital meter. The number shown on the digital meter is the mercury concentration in  $\text{mg}/\text{m}^3$ . This value remains on the display until the next sample is taken. The digital meters automatically zeroes at the start of each sample.

- 6.2.9 **Operating in the SURVEY MODE:** (samples every 3 seconds)

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automatically). *This mode should be used to locate mercury spills or to assess areas of potentially high mercury concentrations. Sampling in this mode is not as accurate as in the SAMPLE mode. Due to the decreased sample volume, the accuracy of the instrument is reduced to +/- 20% @.100 mg/m<sup>3</sup>.*

6.2.9.2 Press and hold the *SAMPLE* button

6.2.9.3 Hold the *SAMPLE* button down until the sensor status indicator bar(s) “\_” begin flashing on the display. Press the *ZERO* button, then release the *SAMPLE* button. The pump should continue to run and the display should update every 3 seconds.

6.2.9.4 The Instrument remains in the survey mode until one of the following occurs:

- The sensor is saturated
- A *LO BAT* (low battery) signal is encountered.
- A *HL* (high mercury level) is encountered
- The instrument is turned off

### 6.3 Turning off the meter:

6.3.1 **Do not allow mercury contamination to stay on film overnight. Regenerate the sensor at the end of use.**

6.3.2 Turn off the instrument by pressing the power *OFF* button. The instrument should always be turned off when not in use.

#### Operation Note(s):

- ❖ *If the sensor is completely saturated, the digital meter display .8.8.8 instead of a value. No further operation is possible until a sensor regeneration is performed.*
- ❖ *The gold film sensors in the analyzer do not respond to the following compounds:*
  - *Hydrocarbons*
  - *CO, CO<sub>2</sub>, and SO<sub>2</sub>*
  - *Water Vapor (water vapor on the gold film can cause irreparable harm to the sensor and must be avoided)*
- ❖ *The acidic gas filter, contained in the internal filter system, removes the following compounds that causes the gold filter to respond:*
  - *Chlorine*
  - *NO<sub>2</sub>*
  - *Hydrogen Sulfide*

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- *Most mercaptans (organic sulfur compounds or “thiols”).*

#### 6.4. Documenting Sampling Results

- 6.4.1. Record readings on a BNL Direct Reading Sampling Instrument Form.
- 6.4.2. Return meter and original copy of the sampling form to the SHSD IH Laboratory.
- 6.4.3. Send a copy of any hazard evaluation report written on the sampling to the IH Laboratory, OMS, and Employee’s supervision.

### 7.0 References

- 7.1 Jerome 431-X Mercury Vapor Analyzer OPERATION MANUAL

### 8.0 Attachments

- 8.1 Instrument Operations: Meter Display Readings
- 8.2 Material Safety Data Sheet for Mercury
- 8.3 Theory of Operation
- 8.4 Photo of the meter
- 8.5 Short Operating Instructions for the Jerome 431-X

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## 9.0 Documentation

<b>Document Review Tracking Sheet</b>		
<b>PREPARED BY:</b> <i>(Signature and date on file)</i> <b>C. Kramer</b> <b>Author</b> <b>Date 01/26/01</b>	<b>REVIEWED BY:</b> <i>(Signature and date on file)</i> <b>R. Selvey</b> <b>SHSD IH Group Leader</b> <b>Date 02/06/01</b>	<b>APPROVED BY:</b> <i>(Signature and date on file)</i> <b>R. Selvey</b> <b>SHSD IH Group Leader</b> <b>Date 02/07/01</b>
RCD Facility Support Procedure Committee Review  <b>04/10/10</b>		RCD Approved By / Date: <i>(Signature and date on file)</i> <b>N. Foster 04/12/01</b> Procedure Committee Review
<b>Filing Code:</b>  <b>IH52QR.01</b>	<b>DQAR</b>  Date	<b>Effective Date:</b>  <b>02/09/01</b>

<b>Periodic Review Record</b>		
Date of Review	Reviewer Signature and Date	Comments Attached
03/09/01	<i>(Signature and date on file)</i> R. Selvey	Renumbered IH-FP-105 to IH75530. Update text to refer to new numbering system.
04/11/01	<i>(Signature and date on file)</i> R. Selvey	Revised to include RCD Facility Support Procedure Committee Review comments.

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**Attachment 8.1**  
**INSTRUMENT OPERATIONS**  
**Meter Display Readings**

**3 INSTRUMENT OPERATION**

**3.1 DIGITAL METER DISPLAY CODES**

METER DISPLAY	EXPLANATION
000	Ready to sample
.000	Lack of mercury reading
00.0	Lack of mercury reading, display in nanograms (see page 17)
.8.8.8	Perform sensor regeneration (refer to page 6)
.H.H.H	Sensor regeneration in progress (.H.H.H flashes)
.L.L.L	Perform re-zero (refer to page 6)
.P.P.P	Power cord required or low line power, <100 VAC (or 200 VAC)(see page 17, Changing the Fuse, if .P.P.P remains on after the cord is connected.)
.H.L.P	High line power, greater than 130 VAC (or 260 VAC)
.LO BAT	Recharge batteries (refer to page 10)
.E.E.E	Same as LO BAT, automatically shuts off
.HL	High level, sample exceeded maximum sample limit (.999)
<b>DURING SAMPLING</b>	
.-	0-25% sensor saturation
.-.	25-50% sensor saturation
.-.-	50-75% sensor saturation
.-.-.	75-100% sensor saturation
<b>DURING SAMPLING</b>	<b>USING THE SURVEY MODE</b>
-	Survey sampling (minus sign flashes continuously)
<b>WHEN ZERO IS DEPRESSED</b>	Adjust to 0 <i>only</i> after sensor regeneration. It is normal for the display to read H after sampling has started.
0	Zero, ready to sample
H	High, turn Zero pot counterclockwise
L	Low, turn Zero pot clockwise

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## Attachment 8.2 Material Safety Data Sheet For Mercury

<b>MATERIAL SAFETY DATA SHEET</b>	
<p>Date of Issue 04/95</p> <p><b>10.2 MERCURY</b></p> <p>ARIZONA INSTRUMENT CORPORATION                      4114 East Wood Street                      Phoenix, AZ 85040                      INFORMATION HOTLINE (800) 235-3360</p> <p><b>Product Identification:</b>                      CHEMICAL NAME: Mercury metal                      TRADE NAME &amp; SYNONYMS: Quick Silver                      CHEMICAL FAMILY: Metals                      FORMULA: Hg                      FORMULA WEIGHT: 200.59</p> <p><b>Section 1 - Physical Data</b>                      ODOR: Odorless                      SPECIFIC GRAVITY (H<sub>2</sub>O = 1): 13.54                      VAPOR PRESSURE AT 20°C (mmHg): 0.0012                      BOILING POINT, 760 mm Hg (°C): 356.9                      MELTING POINT (°C): -38.9</p> <p><b>Section 2 - Fire and Explosion Data</b>                      FIRE HAZARD: Nonflammable                      UNUSUAL HAZARDS: Extremely toxic vapors upon exposure to high temperatures.</p> <p><b>Section 3 - Reactivity Data</b>                      STABILITY: Stable at room temperature                      INCOMPATIBILITIES AND REACTIVITIES: Acetylene, ammonia, chlorine dioxide, azides, calcium (amalgam formation), sodium carbide, lithium, rubidium, copper, nitric acid</p> <p><b>Section 4 - Leak/Spill Disposal Information</b>                      PRODUCT CLEAN-UP: Recover with suction cup equipped with a capillary tube.                      DISPOSAL METHOD: Perform in compliance with all current local, state and federal regulations.</p>	<p><b>Section 5 - Health Hazard Information</b>                      EXPOSURE LIMIT                      0.05mg/m<sup>3</sup> (NIOSH/TWA)                      0.100mg/m<sup>3</sup> Ceiling (OSHA)</p> <p><b>EXPOSURE/HEALTH EFFECTS:</b> Coughing, bronchitis, pneumonia, tremor, insomnia, irritability, headache, fatigue, weakness, stomatitis, weight loss, GI disorder  <b>SKIN &amp; EYES:</b> Can irritate skin and eyes  <b>FIRST AID:</b>                      SKIN: Wash with water, get medical assistance.                      EYES: Wash with water, get medical assistance.                      INHALATION: Remove to fresh air, get medical assistance.                      INGESTION: Get medical assistance.</p> <p><b>Section 6 - Special Protection Information</b>                      Ventilation must be sufficient to meet TLV. Wear rubber gloves and eye protection.</p> <p><b>Section 7 - Special Handling and Storing Precautions</b>                      Do NOT heat mercury unless appropriate safety precautions for highly toxic vapors have been taken. Store in sealed container.</p> <p><b>Section 8 - Hazardous Ingredients</b>                      Mercury and Mercury vapor</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>The information and recommendations set forth herein are presented in good faith and believed to be correct as of the date hereof. Arizona Instrument Corporation, however, makes no representations as to the completeness or accuracy thereof and information is supplied upon the condition that the persons receiving same will make their own determination as to its suitability for their purposes prior to use. In no event will Arizona Instrument Corporation be responsible for damages of any nature whatsoever resulting from the use of or reliance upon this information.</p> </div>
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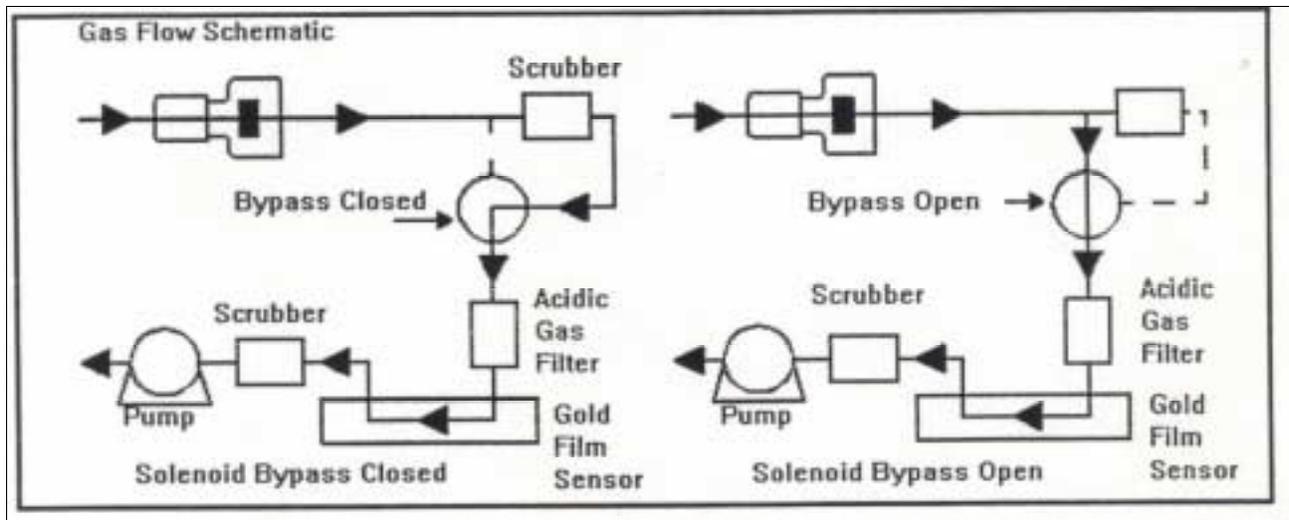
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### Attachment 8.3 Theory of Operation

Activating the sample mode of the Jerome 431-X Gold Film Mercury Analyzer starts an internal pump which draws air through a scrubber filter and into the flow system. After 2 seconds, the sample solenoid bypass opens, closing off the scrubber filter from the flow system. The sample air passes through a filter (removing any acidic gases which interfere with the sensor's response to mercury) and is drawn over the gold film sensor. The sensor adsorbs and alters the electrical resistance in response to the mercury vapor. Nine seconds after starting, the sample solenoid bypass closes and the remainder of the sample is drawn through the scrubber filter and the flow system. The measured concentration is then displayed on the digital meter in milligrams per cubic meter (mg/m<sup>3</sup>) of mercury.

Mercury is unique in its ability to alter the resistance of gold film. The Jerome 431-X sensor consists of two thin fold films, a reference and a sensor, configured in a Wheatstone Bridge circuit, which detects very small changes in electrical resistance. The reference film is sealed and not exposed to mercury. The sensor film is exposed to mercury resulting in resistance changes, which are measured by the circuit. A microprocessor computes the concentration of mercury vapor and displays the results.

During the sample cycle, bars on the digital meter represent the percentage of sensor saturation. Approximately sixty-five samples containing 0.1 mg/m<sup>3</sup> Hg may be taken before the sensor reaches saturation. After absorbing approximately 500 nanograms of mercury, the sensor becomes saturated and needs to be cleaned. This is accomplished by a manually activated 10 minute heat cycle, or sensor regeneration, which burns the mercury from the sensor. This mercury is absorbed on internal filters to prevent any external contamination. The solenoid bypass closes during the sensor regeneration cycle, causing the air to pass through the scrubber filter, providing clean air for the regeneration process. The flow system's scrubber prevents contamination to the atmosphere from the desorbed mercury.



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**Attachment 8.4**  
**Photo of the Meter**



**Probe**

**ZERO**

**REGENERATION**

**ON**

**OFF**

**SAMPLE**

**Display Function  
Descriptions**

**Switch Function  
Descriptions**

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### Attachment 8.5 Short Operating Instructions for the Jerome 431-X

	Step	User Action	Meter Display
1	<b>Power ON</b>	Plug into AC power. Press the power <i>ON</i> . Allow 1 minute for the unit to warm up.	<b>000</b>
2	<b>Sensor Regeneration</b>	Press <i>REGEN</i> . (10 minute regeneration cycle)	<b>.H.H.H</b> flashes
3	<b>Zero</b>	Press <i>ZERO</i> and adjust screw under the handle until the display reads "0".	<b>0</b>
4	<b>Bump Check</b>	Sample the headspace of a vial of mercury and observing the response	Should read a positive number
5	<b>Single Sample Mode</b>	Press and hold the <i>SAMPLE</i> . When finished, release the <i>SAMPLE</i> . (For maximum accuracy, wait 30 minutes after the sensor regeneration cycle to zero the unit).	At the end of 12 seconds, the mercury concentration is shown in mg/m <sup>3</sup> .
6	<b>Survey Mode</b>	Hold the <i>SAMPLE</i> until the sensor status indicator bar(s) "_" begins flashing. Press the <i>ZERO</i> , then release the <i>SAMPLE</i> . (Meter samples every 3 seconds automatically. The accuracy of the instrument is reduced to +/- 20% @ .100 mg/m <sup>3</sup> .)	<b>"_"</b> flashes
7	<b>Power OFF</b>	Press <i>REGEN</i> . Regenerate the sensor at the end of use. Then turn off the instrument by pressing <i>OFF</i> .	<b>.H.H.H</b> flashes