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BROOKHAVEN NATIONAL LABORATORY Safety & Health Services Division INDUSTRIAL HYGIENE GROUP Standard Operating Procedure: Field Procedure	NUMBER IH99400
	REVISION FINAL rev 0
SUBJECT: HI3702 Induced Current Meter	DATE 08/05/05
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1.0 Purpose/Scope

This procedure provides a standardized method for the operation of the HI3702 Induced Current Meter with the HI 4416 System Readout. It should be used in conjunction with the SBMS Subject Area *RF and Microwave Radiation* and IH SOP IH-99150 *Radiofrequency and Microwave Measurement Principles: Area Surveys*.

The HI-3702 Clamp-On Induced Current Meter measures the induced body current of individuals working in environments where radio frequency (RF) electromagnetic fields are present. It meets the measurements requirements as specified in the BNL Subject Area, the American Conference of Governmental Industrial Hygienists, and the Institute of Electrical and Electronics Engineers Specification ANSI C95.1-1991.

This meter is used to

- Determine the personal exposure to RF sources,
- Determine if inclusion in a medical surveillance program is required,
- Determine the need for additional personal monitoring.

The unit is designed to measure RF induced current flowing through ankles or arms of the body, even while walking or climbing, during short periods of time (about 2 minutes). The signal generated by the sensor is transmitted via the fiber optic interface to the HI-4416 Readout/control Unit.

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2.0 Responsibilities

- 2.1 Use of this SOP shall be limited to persons acting under the direction of a competent hazard assessor who has demonstrated the competency to satisfactorily use the procedures and meter, as evidenced by experience and training, to the satisfaction of their supervision or existing qualification criteria set by their organization.
- 2.2 Personnel that perform exposure monitoring with this procedure 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.

3.0 Definitions See also IH procedure 99150

Induced Current: Movement by a person in a static or alternating magnetic field will induce (create) a flow of electric current within the person when the person is grounded. This is the *induced current* that this meter reads.

4.0 Prerequisites

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

- 4.1.1 Demonstration of proper operation of the instrument to the satisfaction of the employee's supervision as determined in Section 7.
- 4.1.2 Review of the SBMS Subject Area *RF and Microwave Radiation*.

4.2 **Area Access:**

- 4.2.1 Contact the appropriate Facility Support Representative or FS Technician to obtain approval to enter radiological areas. Complete appropriate training for the area to be entered.
- 4.2.2 Verify with the appropriate Facility Support Representative or FS Technician if a Work Permit or Radiological Permit is needed or is in effect. If so, review and sign the permit.
- 4.2.3 Use appropriate PPE for area.

5.0 Precautions

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5.1 Hazard Determination:

- 5.1.1 The operation of an area survey meter does not create exposure to any chemical, physical, or radiological hazards. The meters do not generate hazardous waste. The meter design does not cause significant ergonomic concerns in routine use.
 - 5.1.2 The meter is sensitive and can be burned by entry into fields above their capacity. Approach the source from a low background.
 - 5.1.3 The primary hazard from rf/microwave is heating of the body. The eyes and genitals/reproductive organs are the most sensitive. Prolonged exposure to very high sources can result in death to the individual.
 - 5.1.4 Consult Job Risk assessment IH-JRA-05 for additional risk and control measure evaluation.
- 5.2 In high field areas with high standing waves or high reflections, high currents may be induced in the probe cable and handle. In such areas, it may be advisable to use a resistive cable such as are provided in the Holaday Industries extension cables.

5.3 Personal Protective Equipment:

- 5.3.1 If high fields are expected, the NARDA Alert alarming meter can be used to alarm in high fields. Verify that the frequency of the fields present in the work area are covered by this instrument (30 kHz to 100 MHz.).
- 5.3.2 Rf /microwave protective clothing is not available. Rely on engineering and administrative controls such as remaining a safe distance from the source as indicated by this direct reading meter.
- 5.3.3 Additional PPE: Other appropriate PPE for hands, feet, skin, head, or eyes may be needed for the area being entered. Check with the area FS Representative.

6.0 Procedure

The Model IHI-3702 system includes the following items:

- Model HI 3702 Clamp-On Current Sensor with cushioned case
- HI-4416 Digital Readout/Control Unit with Fiber Optic Cable.
- Standard Fast Charger (115/230 V)

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6.1 **Calibration:** Determine if the meter is in calibration, as per IH51660. The meter can only be factory calibrated.

6.2 **Check the battery for both the HI 3702 (Clamp on Induced Current Meter) and the HI4416 (System Readout):** The batteries will self-discharge to zero after 2 months. Charge the batteries to the maximum capacity before use (1 hour with a Series 491135 NiCad Battery Fast Charger.)

To charge a low battery on the HI 3702: Turn off the clamp-on sensor. Plug the charger into an AC outlet. Plug the charger jack all the way into the charge receptacle on the sensor. Verify that the amber light on the charger unit is lit, indicating that the unit is charging. Allow approximately 1 hour for a full charge cycle. NOTE: When charging is complete the charger automatically goes into a trickle charge and will continue to do so until the HI-3702 is disconnected. At the completion of the cycle, remove from the charger and unplug the charger from the AC outlet. Use the HI-4416 to verify that the battery is charged to approximately 3.8 VDC.

6.3 **Operating instructions**

6.3.1 Connect the fiber optic cable to the HI-4416 and the HI-3702. The connections are color coded.

6.3.2 Turn on the HI-3702. The locking “on-off” switch must be pulled out before toggling it to the appropriate position. Make sure the switch on the probe is in the Auto Range position

6.3.3 Turn the HI4416 ON. All segments of the LCD will activate for 2 seconds, the software version will display, the current range of the probe will display, and then the readout switches to measurement operation. NOTE: The HI 4416 does not shut down automatically, so be sure to turn the instrument off when not in use.

6.3.4 Use the “Mode Select” key to move the cursor through the columns in the display panel.

6.3.5 Set the range that is appropriate for the expected current levels to be measured. The HI-3702 has **autoranging** capability (Range A) when connected to the HI-4416. This is the default setting and it is suggested that this is the setting to be used.

Autorange (Range A)	1.00-mA-1.000 A
Range 1:	1.00-mA-1.0 mA
Range 2:	3.1 mA – 31.6 mA

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Range 3:	10.0-mA-100.0 mA
Range 4:	0.031 mA – 0.316 A
Range 5:	0.100 A-1000 mA

6.3.6 Set the data collection rate. The choices are “Instantaneous Readings (X-axis)” or “One Second Averaging (Y-axis)” and are set by selection of the X, Y, or Z axis. **Select the Y-axis**, as this conforms to the requirements of the ACGIH standard (I is averaged over any 1-second period). When the X-axis is selected, each measurement is sent to the display. When the Y-Axis is selected, the one-second average of the measurements is being displayed. The averaging algorithm stores the seven most recent measurements. Each time a measurement is taken, the algorithm drops the oldest value, adds in the new value, then recalculates the average and sends the new average value to the display.

Note: Displayed readings that are less than 10% of the full scale reading for the selected range are not valid. When “Range 1” or “Autorange” is select and there is no current passing through the current meter, a noise floor reading will be displayed. This is a normal operating condition.

6.3.7 Place the clamp-on current sensor on the arm or leg of the person and close the buckle. Be sure that no pieces of clothing get caught between the surfaces. Note: the meter will record 150 seconds of data before filling the memory. This equals about 2.5 minutes. For longer jobs, have the worker return and record the data and then reset the memory.

6.4 Recording readings:

6.4.1 After the workers returns from the work area, access the stored data by using the “Prev” and Next” keypads. The stored data will be displayed. Up to 150 data points can be stored, representing 150 seconds (2.5 minutes). The data is stored as 149 data points in sequential order and then all new data points replace the 150th data point. Press the “Max” keypad to record the highest exposure level. Note: The record output send a DC voltage proportional to the field. BNL does not use this feature.

6.4.2 Use a Direct Reading Sampling Instrument Form or *equivalent* to record readings and additional required information.

6.4.3 Return meter and original sampling form to the SHSD IH Laboratory.

6.4.4 Ensure that a copy of any hazard evaluation report written by a competent person on the survey is sent to the IH Laboratory and the Occupational

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Medicine Clinic, the department ESH coordinator, and the individuals surveyed.

6.5 Calculations and determination of compliance with occupational exposure standards

The acceptable levels range (based on ACGIH TLVs) is:
 Induced and Contact Current Maximum Current (mA)

Frequency	Through both feet	Through either foot	Contact	Averaging Time
30 kHz – 100 kHz	2000 f	1000 f	1000 f	Any 1 second interval
100 kHz – 100 MHz	200 f	100	100	6 minutes period

6.5.1 The results displays in the units milliamps per meter squared. (mA/m)².

6.5.2 If values are greater than or equal to 50% of the standard, refer the individuals to the Occupational Medicine Clinic for inclusion in the RF protocol. Further review should be made to determine what additional controls or procedures should be instituted.

6.6 Computer controlled Data Logging: A dedicated computer is required as well as additional cables. This application is not covered in this SOP.

7.0 Implementation & Training

7.1 Use of this SOP is limited to:

- 7.1.1 Persons who act under the direction of a competent hazard assessment person
- 7.1.2 Persons who have demonstrated the competency to satisfactorily use the procedures and meter, as evidenced by experience and training, to the satisfaction of their supervision or existing qualification criteria set by their organization.

7.2 For the SHSD IH Group personnel:

- 7.2.1 Qualification on this Job Performance Measure (JPM) is required on a 3 year basis.

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7.2.2 Personnel are to document their training using Attachment 9.4 *Job Performance Measure Completion Certificate*.

7.3 Training for entry into restricted areas may be required (check with ESH coordinator or FS Representative for the facility).

8.0 References

- 8.1 ACGIH Documentation of TLVs. American Conference of Governmental Industrial Hygienists.
- 8.2 SBMS Subject Area *RF and Microwave Radiation*
- 8.3 Holaday Industries, Inc. HI-3702 User's Manual #600070E, copyright 1999.
- 8.4 Holaday Industries, Inc. HI-4416 system readout User's Manual, (no rev or date)

9.0 Attachments

- 9.1 Photo of parts
- 9.2 Photo of parts
- 9.3 Error codes & Mode settings
- 9.4 Mode & Display settings on HI-4416
- 9.5 Qualification Job Performance Measure

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10.0 Documentation

Document Development and Revision Control Tracking		
Prepared By: <i>(signature/date on file)</i> N. Bernholc 06/13/05 <small>Certified Industrial Hygienist</small>	Reviewed By / Date: <i>(signature/date on file)</i> R. Selvey 07/15/05 <small>Certified Industrial Hygienist</small>	Approved By / Date: <i>(signature/date on file)</i> R. Selvey 08/05/05 <small>Industrial Hygienist Group Leader</small>
ESH Coordinator/ Date: <i>none</i>	Work Coordinator/ Date: <i>none</i>	SHSD Manager / Date <i>none</i>
QA Representative / Date: <i>none</i>	Training Coordinator / Date: <i>none</i>	Filing Code: IH52.05
Facility Support Rep. / Date: <i>none</i>	Environ. Compliance Rep. / Date: <i>none</i>	Effective Date: 08/05/05
ISM Review - Hazard Categorization <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low/Skill of the craft	Validation: <input type="checkbox"/> Formal Walkthrough <input checked="" type="checkbox"/> Desk Top Review <input type="checkbox"/> SME Review Name / Date: N. Bernholc 7/28/05	IMPLEMENTATION: Training Completed: n/a Procedure posted on Web: 08/05/05 Hard Copy files updated: 08/05/05

Revision Log		
Purpose: <input type="checkbox"/> Temporary Change <input type="checkbox"/> Change in Scope <input type="checkbox"/> Periodic review <input type="checkbox"/> Clarify/enhance procedural controls Changed resulting from: <input type="checkbox"/> Environmental impacts <input type="checkbox"/> Federal, State and/or Local requirements <input type="checkbox"/> Corrective/preventive actions to non-conformances <input type="checkbox"/> none of the above Section/page and Description of change:		
<i>(signature/date on file)</i> SME Reviewer/Date:	Reviewer/Date:	Reviewer/Date:
Purpose: <input type="checkbox"/> Temporary Change <input type="checkbox"/> Change in Scope <input type="checkbox"/> Periodic review <input type="checkbox"/> Clarify/enhance procedural controls Changed resulting from: <input type="checkbox"/> Environmental impacts <input type="checkbox"/> Federal, State and/or Local requirements <input type="checkbox"/> Corrective/preventive actions to non-conformances <input type="checkbox"/> none of the above Section/page and Description of change:		
<i>(signature/date on file)</i> SME Reviewer/Date:	Reviewer/Date:	Reviewer/Date:

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Attachment 9.1

Photo of the Model 3702 Clamp-On Induced Current Meter



Opening to place meter over arm
or leg of individual

Connections to Charger and Readout

Match colors of wires to connect to
readout system see below.

Pull "Off/ On" toggle switch in order to
change setting.

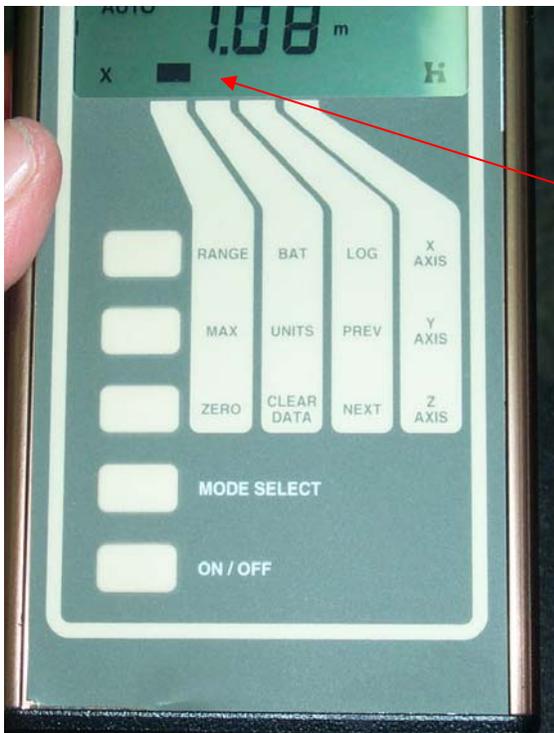


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Attachment 9.2

Photo of the HI-4416 System Readout



Note line above column, indicating which functions may be selected. (In this case Range, Max and Zero).

Pressing "Mode Select" will change the line to the next column and new functions (e.g. bat; units,



Series 491135 NiCad Battery Fast Charger



TOP: Connections to charger and induction meter.

Connect fiber optic cable on readout unit (follow color code) and then connect to the induced current meter clamp on probe.

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Attachment 9.3

Error Codes and Hi-4416 Display Values

Communication Error Codes Under certain circumstances it is possible for the user to correct the conditions causing errors 01 and 02: If not, or if the conditions generate errors 03-12 develop and persist, the probe must be repaired.

Error Number	Cause
E01 No Response From Probe	Probe's ON/OFF switch in OFF position; Faulty probe
E02 Transmission Error (e.g., Parity)	The HI-4416 is ON, no fiber optic cables are connected, and the readout's connectors are aimed toward a light source; Faulty probe
E03 Input Buffer Overflow	Too many characters contained between the Start Character/ Carriage Return sequence
E04 Invalid start character for probe data	Start character incorrect or not sent
E05 Probe Data String Length Error	Data string does not conform to one of the two correct string lengths
E06 Invalid String for Reading Value	Data string doesn't conform to correct format (four digits plus decimal point)
E07 Invalid Range Value	Incorrect range characters
E08 Invalid Unit Value	Incorrect unit characters
E09 Invalid Axis Enable Value	Value is other than "E" or "D"
E10 Invalid Battery Status Value	Value is other than "N", "D" or "F"
E11 Over Range Indicator	Value is other than "N" or "O"
E12 Invalid Recorder Out Value	Value is not in the range 0-225

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Attachment 9.4

Mode & Display settings on HI-4416

RANGE	BAT	LOG	X AXIS
MAX	UNITS	PREV	Y AXIS
ZERO	CLEAR DATA	NEXT	Z AXIS

Range	The range is from 1.00 mA to 1000 mA and is reported in mA/m ² . If "r A" or auto range does not display, scroll through the ranges until "R A" appears on the display. Note: When Autorange is enabled, the probe will scroll up to the next higher range when the reading displayed exceeds full scale. The probe will scroll down to the next lower range when the reading displayed is (20%) of the full scale reading for the current range. This will put the reading at approximately 2/3 of full scale of the next lower range.
Max	Displays maximum value since the last time the key pad "Max" was pressed or the meter turned on.
Zero	Clears signal data from the meter probe. Should only be pressed in an area known to be free of non-ionizing radiation fields.
Bat	Displays the PROBES battery voltage
Units	Commands the probe to change units of measure and displays the new units. Units are mW/cm ² ; mG uT; nT; k[V/m] ² ; m{A/m} ² . Because the HI-4416 is used with many Holaday probes, not all units are applicable to the HI-3702. As set up at BNL, the only valid units are mA/m ²
Clear Data	This clears all readings out of the data log memory. Press and hold the CLEAR DATA keypad. "CLR" will flash on the screen for approximately two seconds. Continue pressing the keypad until "000" appears on the display. The data log memory is now cleared. When you release the key, the system will return to measurement mode. NOTE: IF this keypad is released while the "CLR" characters are still flashing, data log memory is unaffected. This helps prevent accidental erasing of data.
Log:	Saves the current measurement in data log memory. Pressing the LOG keypad saves the reading in memory. As this occurs the readout momentarily displays the three-digit identification number of the reading. The data stored includes values, units of measure, over/under range indication and active axes. Up to 150 measurements may be stored. When data log memory is full, any additional log operations replace the value previously stored in location 150 with the new value. All other memory locations remain unchanged.
Prev:	Accesses the last value stored in data log memory. When the key is pressed: 1) the three-digit identification number of the stored value is displayed for approximately one second, 2) the stored value is displayed. The readout continues to display this value as long as the PREV key remains pressed.
Next:	Similar function to previous, but it displays the next value stored in data log memory.
X Axis:	Commands the probe to enable/disable x Axis measurements
Y Axis:	Commands the probe to enable/disable y Axis measurements
Z Axis:	Commands the probe to enable/disable z Axis measurements

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Attachment 9.5

Practitioner Qualification Form

(see next page)

Safety and Health Services Division - Industrial Hygiene Group
Non-Ionizing Radiation Program

Qualification Certificate: Job Performance Measure
HI-3702 Clamp-On Induced Current Meter Operation

Candidate's Name (Print):	BNL#
Qualified By: <i>IH Group Leader</i>	Date of Qualification

Practical Skill Evaluation: Demonstration of Principles by Oral Exam

Criteria	Qualifying Performance Standard	Unsat.	Recov.	Satisf.
1. Hazard Analysis	Understands the need to perform a hazard analysis of the area and potential exposure to the self as sampler and workers in the area.			
2. Personal Protective Equipment	Understands the need to be aware of the potential surface contamination, airborne levels of contaminants, radiological hazards, and noise hazard. Knows how to determine the need for PPE.			
3. Sampling Equipment	Knows where equipment needed for the procedure is located and how to properly sign it out.			
4. Pre-Testing Inspection	Verifies the system to be monitored is operational and represents typical operation. Makes notation in sampling record if the operating conditions are atypical.			
5. Measurement of hazard	Knows how to properly measure employee exposure to hazardous NIR levels.			
6. Operating Parameters	Knows the theory to establish operating parameters (safety envelope) for the equipment. Make drawing or photo. Measure.			
7. Documentation	Demonstrates correctly filling out IH monitoring forms.			

Practical Skill Evaluation: Demonstration of Methodology

Criteria	Qualifying Performance Standard	Unsat.	Recov.	Satisf.
1. Determining the need for investigation	Demonstrates knowledge to determine the appropriate assessment parameters.			
2. Conducts appropriate interviews	Demonstrates knowledge in conducting interviews with supervision, the worker and co-workers to determine exposure characteristics.			
3. Conducts hazard assessment	Demonstrates knowledge in conducting appropriate dosimetry to determine exposure potential in the work operations.			
4. Documentation	Demonstrates correctly filling out IH forms, transfers appropriate info to IH databases, prepares an evaluation assessment report (including an evaluation of the relationship of the exposure to occupational exposure limits), and notify workers and management of the results.			

Meter Operation Practical Skill Evaluation: Demonstration of Methodology

Criteria	Qualifying Performance Standard	Unsat.	Recov.	Satisf.
Set-up	Demonstrates how to correctly attach the probe to the meter.			
Clear Data and log memory	Demonstrates how to correctly reset data and memory in the meter.			
Placement on Work	Demonstrates how to correctly place the probe on the worker.			
Operating the meter to record data	Demonstrates how to correctly operate the meter.			
Downloading Data	Demonstrates how to successful down logged data from the meter.			

I accept the responsibility for performing the tasks as demonstrated within this JPM and the corresponding SOP.

Candidate Signature:	Date:
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I certify the candidate has satisfactorily performed each of the above listed steps and is capable of performing the task unsupervised.

Evaluator Signature:	Date:
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