# Chapter 8 – Equipment Maintenance and Calibration

## 1. General

a. The maintenance and calibration of industrial hygiene (IH) equipment is critical to ensure that precise and accurate measurements of the workplace are made. Many far-reaching decisions are based on the results of workplace evaluations of toxic chemicals or harmful physical agents. An underestimation of an employee’s or group of employees’ exposure may result in medical as well as legal complications. Overestimation may result in costly and unnecessary control measures, reduced production and employee relations problems.

b. Determination of any given employee’s "actual" exposure is a difficult task. To minimize errors and most closely approximate employees’ exposure, it is necessary to have a comprehensive calibration program in addition to professional experience, sound sampling strategies and established analytical procedures.

## 2. Scope

This chapter provides the requirements for calibration and maintenance of all Navy IH equipment. Although the calibration of most Navy technical equipment is covered by the Metrology Requirements List (METRL), NAVSEA Publication OD 45845 (Reference 8-1) under the Metrology Engineering Center, Pomona, California, medical and industrial hygiene equipment has generally not been included in this calibration program. One notable exception is the calibration of heat stress meters by METCAL facilities. Although use of METCAL facilities is an option, use of this calibration source is not required since many items of industrial hygiene equipment are neither handled by nor familiar to METCAL facilities. This chapter does not apply to RADIAC equipment.

## 3. Responsibilities

Each command owning industrial hygiene equipment must be responsible for the correct operation, maintenance and calibration of that equipment.

## 4. Calibration, Checks and Maintenance

a. General. Most types of industrial hygiene equipment require periodic laboratory calibration. Many must also be field calibrated or field checked by the user. Examples of field calibrated items are personal sampling pumps, sound level meters, rotameters, toxic gas monitors, combustible gas monitors, and oxygen meters. An example of an item that must be field checked but cannot be calibrated is a hand-held sampling pump for detector tubes.

b. Periodic Laboratory Calibration. Certain equipment must be calibrated periodically by a calibration laboratory, recommended calibration laboratories are those operated by the equipment manufacturer (who is the most familiar with the equipment), the Navy and Marine Corps Public Health Center (NMCPHC) Calibration Laboratory, or other qualified calibration laboratories. Examples of other qualified laboratories would be those recommended by the manufacturer or those with a demonstrated ability to calibrate a specific piece of equipment and a quality control program which provides traceability to National Institute of Standards and Technology (NIST) standards.

c. For NMCPHC Calibration Laboratory.
   (1) The updated list of Sound Level and Audiometric Equipment currently serviced by the NMCPHC Calibration Laboratory can be found in Appendix 8-A. This service is available at no cost to Bureau of Medicine and Surgery (BUMED) supported activities. The equipment will be checked to conform to the manufacturer's specifications and comply with the appropriate ANSI standards.
   (2) Due to the volume of equipment requiring calibration, major repairs will not be performed at this time. Equipment not meeting manufacturer's specifications or those in need of repair will be returned with a recommendation that it be sent to the manufacturer for repair. To minimize backlog and achieve a 20-working day turnaround time, it is requested to limit your shipment to ten (10) pieces of equipment per order.
   (3) Currently, we have Operator's Manuals to calibrate the equipment listed. If you have equipment not listed, please send a copy of the instruction manual with the unit.
   (4) When sending equipment in for service, furnish a complete return address with the point-of-contact, department/division, building number, street number & name, city, state, zip code and telephone number. Pack the equipment in at least a double-wall carton, wrapped in bubble wrap and ship by traceable source to:

Commander
Navy and Marine Corps Public Health Center
Attn: Calibration Laboratory
620 John Paul Jones Circle, Bldg. 3 Suite 1100
Portsmouth, VA 23708-2103

   For further information, please call the NMCPHC Calibration Laboratory, 377-0790 (DSN) or (757) 953-0790 (commercial).

d. Calibration Schedule. Appendix 8-B lists general equipment laboratory and field calibration intervals. If conflicts exist with individual manufacturer's requirements, the manufacturer's requirements take precedence.

e. Shipboard Industrial Hygiene Equipment Calibration. Equipment aboard ships is entered in the ship's calibration program for periodic recall. The tender or Shore Intermediate Maintenance Activity will send the equipment to the appropriate calibrating authority.

f. Equipment Maintenance and Repair. Maintenance shall be conducted in accordance with the manufacturer's recommendations and, for shipboard equipment, per the Planned Maintenance System (PMS) requirements.

(1) Routine field maintenance, such as replacing batteries, changing filters, and replacing minor components (i.e., normal end-user maintenance described in the manufacturer's operator's manual) may be accomplished by the user, provided the user has the necessary expertise.
(2) More complex maintenance or repairs should be accomplished by the manufacturer or similar specialized repair facility.
(3) Great care should be taken to ensure that the calibration or operation of the equipment is not adversely affected by the maintenance or repairs. Whenever any repair is accomplished which can affect the instrument's calibration (e.g., work on internal electronic circuits, replacement of circuit boards, repair after being dropped or hit), the instrument should be recalibrated by the manufacturer or at a qualified calibration laboratory. Minor repair actions such as reconnecting a broken battery lead may do not require a laboratory recalibration.
(4) An adequate supply of spare replacement parts should be maintained by the user to allow timely repair of equipment when such repair is within the user's capabilities.

## 5. Batteries

Always check the instrument manufacturer's instruction manual for the proper batteries to use. If a piece of equipment is designed to work with alkaline batteries, for example, it may not function properly with carbon zinc cells. The most commonly used types of batteries are listed below.

a. Carbon Zinc Batteries. These cells are the least costly, but, in general, have a short life under continuous use and are not rechargeable. The most commonly used cell sizes are AAA, AA, C, D, and the rectangular shaped 9 volt. To prevent equipment damage due to leakage, always remove carbon zinc batteries from the instrument when not in use. Do NOT attempt to recharge carbon-zinc batteries.

b. Alkaline Batteries. Alkaline cells are more expensive than carbon zinc but have a more stable voltage output and longer service life. Certain instruments require that only alkaline batteries be used. They come in the same cell sizes as carbon zinc batteries. Alkaline batteries are less prone to leakage but should also be removed from instruments when not in use. Rechargeable alkaline batteries are now available but before recharging an alkaline battery verify that the battery is rechargeable and that the charger is intended for use with alkaline batteries (i.e., a nickel-cadmium battery charger cannot be used to recharge alkaline batteries).

c. Nickel-Cadmium (Ni-Cad) Batteries.
(1) Rechargeable Ni-Cad batteries should be charged only in accordance with manufacturer's instructions. Chargers are generally designed to charge batteries quickly (approximately 8 to 16 hours) at a high charge rate or slowly (trickle charge). A battery can be overcharged and ruined when a high charge rate is applied for too long a time; however, some Ni-Cad batteries may be left on trickle charge

indefinitely to maintain them at peak capacity. Refer to the manufacturer's instructions for charging guidance for a specific instrument.

(2) It is undesirable to discharge a multi-celled Ni-Cad battery pack to voltage levels which are 70 percent or less of its rated voltage - doing so can drive a reverse current through some of the cells which can permanently damage them. When the voltage of the battery pack drops to 70 percent of its rated value, it is considered depleted and should be recharged. Modern instruments contain circuits that turn the instrument off before this point is reached.

d. Rechargeable Battery Packs. Battery condition circuits are built into many modern instruments and give a good indication of remaining battery life. Older instruments may require the use of a voltmeter to measure battery charge. Always check battery voltage under load and after 5 minutes of operation to allow the voltage to stabilize. If using a voltmeter, take extreme caution not to short circuit the battery terminals. Some battery packs contain a current limiting resistor, which a short circuit will cause to burn out, necessitating a costly battery pack replacement.

e. Lithium Batteries. These batteries offer longer life, but the higher current may affect the operation of the equipment. If the manufacturer does not specify lithium battery use, consult the manufacturer before using.

## 6. Explosive Atmospheres

No instrument shall be used in flammable or explosive atmospheres unless the instrument is certified intrinsically safe by the Mine Safety and Health Administration (MSHA), Underwriter's Laboratory (UL), IFM Approvals LLC (FM), or another testing laboratory recognized by the Occupational Safety and Health Administration (OSHA) for the type of atmosphere present (Nationally Recognized Testing Laboratories (NRTLs)). When batteries are being replaced, use only the type of battery specified by the manufacturer.

**CAUTION:** The intrinsic safety seal applies to the pump, but not usually to the charger or the docking station. Do NOT charge battery packs or docking stations in an explosive atmosphere.

## 7. Field Calibration of Personal Sampling Pumps

The same type of media/devices (e.g., glass fiber filter preceding impinger) used to collect the sample must be in line during calibration. However, do not use the actual media (filter cassette/sorbent tube) intended for sampling use to perform calibration. Calibrate personal air sampling pumps before and after use, on the day of sampling, using one of the calibration methods listed below. Calibration should be performed at the same altitude (pressure) and temperature as sampling is to be conducted. If this is not possible, consult the operating manual for the personal air sampling pump to determine if the air volume needs to be adjusted for temperature and pressure. Record calibration data on NMCPHC

Form 5100/13 or NMCPHC Form 5100/14, as appropriate.

a. Bubble Burette Method. This is a primary calibration standard.
   (1) Allow the pump to run 5 minutes prior to voltage check and calibration. Refer to the manufacturer for fully charged voltages.
   (2) Wet the inside of the burette with soap solution.
   (3) Connect the collection device/media, tubing and pump to the bubble burette as appropriate.
   (4) Visually inspect all tygon tubing connections.
   (5) Momentarily submerge the opening of the burette in order to capture a film of soap.
   (6) Draw two or three bubbles up the burette in order to ensure that the bubbles will complete their run, indicating adequate wetting of the inside of the bubble burette.
   (7) Visually observe a single bubble, and using as stopwatch, time the bubble for a known volume (usually 100 ml, 500 ml, or 1,000 ml). Read the bubble at the edge where it touches the glass.
   (8) For each pump to be used for sampling, repeat the procedures described above three times and use the average of the three readings for the flow rate for that pump. All readings should be within 5 percent of the mean. The same cassette and filter may be used for all calibrations involving the same sampling method.
   (9) If the pump is equipped with a rotameter, while the pump is still running, mark the pump or record the position of the center of the float in the pump rotameter as a reference.

   **NOTE:** The ball-type flow meters and rotameters built into most air samplers are primarily intended to serve only as flow indicators and are therefore of low accuracy. Also, there is a different pressure drop across each type of sampling media. Built-in flow meters must be calibrated against an absolute flow standard such as a bubble burette. To attempt to set the flow using only the built-in rotameter, particularly if the sampling media has been changed, will result in sampling rates outside the levels permitted by NIOSH recommendations and/or OSHA regulations.

b. Electronic Soap Bubble Flow Calibrator (bubble meter) Method. This is a primary calibration standard. These units are high accuracy electronic flow meters that provide instantaneous air flow readings and a cumulative averaging of multiple samples. These calibrators measure the flow rate of gases using an “electric eye” to time the travel of a soap bubble and report volume per unit of time. The result is an actual flowrate at the temperature and pressure conditions at the calibration location. The range with different cells is from 1 cubic centimeter per minute to 30 liters per minute.

   (1) All calibrations using this method are performed in accordance with the manufacturers’ instructions. The calibrator is factory calibrated using a NIST traceable standard.
   (2) Maintenance of calibrator:

(a) Clean before use. Remove the flow cell and gently flush with water. Wipe with cloth only. Do not allow center tube, where sensors detect soap film, to be scratched or get dirty. NEVER clean with acetone. Use only soap and warm water. When cleaning prior to storage, allow flow cell to air dry. If a residue exists, it is possible to remove the bottom plate. Squirt a few drops of soap into the slot between base and flow cell to ease removal.
(b) The system shall be leak checked according to the manufacturer's recommendations. A leak check is typically done by connecting a manometer to the outlet hose and evacuating the inlet to a pressure reading determined by the manufacturer. No leakage should be observed if the instrument is functioning properly.
(c) Performance shall be field verified annually against another primary calibration standard (e.g., a one liter glass burette at 1,000 cc/min or another NIST certified bubble or dry flow calibrator for maximum accuracy). The calibrator performance shall be verified to be linear throughout its range.
(d) The instrument shall be returned to the manufacturer for recertification to NIST traceability whenever a field comparison to another primary standard indicates that it may not be functioning correctly.

c. Electronic Dry Flow Calibrator Method. This is a primary calibration standard. These instruments use an electronic timer to measure the time to move a known volume of air which is measured by the travel of a Teflon-coated piston. Results are reported in volume per unit time. The result is in actual flowrate at the temperature and pressure conditions at the calibration location. However, a version which automatically corrects for temperature and pressure is available. Typical features include averaging of consecutive trials and a continual test mode where a new test is started as soon as a test is completed. The main advantage is that no soap solution is needed eliminating problems with spilled soap solution and buildup of soap film residue. The range with different cells is from 1 cubic centimeter per minute to 50 liters per minute. Each flow cell has a linear performance throughout its range. Note: MSA Escort Elf pumps have potential uncertainty error of over 4% with dry piston calibrators, such as the BIOS Defender. To reduce this error an isolating flow restrictor must be incorporated between the pump and the flow meter to create a 20-inch water column, which is sufficient to reduce pressure spikes as per reference 8-3.

(1) All calibrations using this method are performed in accordance with the manufacturers' instructions. The calibrator is factory certified to a NIST traceable standard.
(2) Maintenance of calibrator:
 (a) The manufacturer's internal leak test shall be performed quarterly or whenever damage is suspected.
 (b) Calibration shall be field verified annually against another primary calibration standard (e.g., a one liter glass burette at 1,000 cc/min or another NIST certified bubble or dry flow calibrator for maximum accuracy). The calibrator

performance shall be verified to be linear throughout its range.

(c) The instrument shall be returned to the manufacturer for recertification to NIST traceability whenever a field comparison to another primary standard indicates that it may not be functioning correctly.

(d) Models equipped with integral temperature and pressure sensors require field verification with another unit equipped with these same features at least annually. The unit used for comparison must be within its annual NIST traceable certification.

d. Precision Rotameter Method. The precision rotameter is a secondary calibration device. It may be used in place of a bubble burette or other primary calibration standard if the following procedures are observed:

(1) Calibrate the rotameter with a bubble burette or other primary calibration standard at least quarterly as follows:

(a) Without the precision rotameter in line, connect the pump to the primary calibration standard and adjust the pump flow control to obtain the maximum flow rate (it is not necessary to have sampling media in line for high flow rotameters);

(b) Determine the exact flow rate by repeating three times and calculating the average. Record the flow rate;

(c) Disconnect the primary calibration standard connection and attach the precision rotameter. Record the precision rotameter reading;

(d) Repeat steps (a) through (c) for at least five different flow rates (maximum, minimum, and 3 intermediate);

(e) Plot a curve of actual flow rate versus precision rotameter readings;

(f) Recalibrate the precision rotameter according to steps (a) through (e) after cleaning, at least quarterly, or more frequently if a change in flow characteristics of the rotameter is suspected;

(g) After the precision rotameter has been calibrated, the pump may be set to the desired flow rate by simply connecting it in line with the precision rotameter. The pump flow rate may then be adjusted until the desired precision rotameter reading, corresponding to the desired flow rate determined during calibration, is obtained.

(2) Disassemble and clean as necessary. Always recalibrate after cleaning. Use with care to avoid dirt and dust contamination which may affect the flow.

(3) Use the precision rotameter such that the pressure drop across it is minimal. The precision rotameter should not be used with a ball adjustment valve accessory, nor with any other restriction that would cause substantial pressure drop.

(4) Do not use a precision rotameter in cases where pump pulsation is present.

(5) In order to determine if the desired flow rate is being maintained during sampling, one of the following two methods may be used.

(a) After the flow rate is initially set using the precision rotameter, observe and note the pump rotameter reading. A piece of tape may be placed on the pump housing with a pen mark showing the location of the center of the rotameter ball.

(b) The precision rotameter can be attached to the sampling media, and knowing the desired precision rotameter setting, the pump flow rate can be adjusted. Record any adjustments on the sampling form.

(6) If the pump cannot be readjusted to the initial flow rate, replace the pump.

(7) If barometric or temperature conditions at the sampling site are substantially different than at the calibration site (i.e., approximately ± 40 mm Hg (1,500 feet elevation) or ± 20˚ F change), it is necessary to calibrate the precision rotameter at the sampling site where the same conditions are present. Alternatively, a correction factor can be calculated for temperature and/or pressure, if the conditions at both use and calibration locations are known, and then be applied to the flowrate or volume.

e. Mass Flow Meter Method. The mass flow meter is a secondary calibration device which directly measures the quantity of air flowing through a sensor. The output of the sensor is amplified and fed to a meter that is calibrated directly in liters or cubic centimeters per minute. These devices measure flowrate at standard conditions and do not require corrections for temperature and pressure since they are location independent.

(1) A mass flow meter must be field calibrated quarterly in much the same manner as a precision rotameter, using a pump and bubble burette or other primary calibration standard to determine the flow rate. Disconnect the primary calibration standard, connect the mass flow meter, and record the results. As in the procedure for a precision rotameter, take readings at 5 different flow rates. If the flow rates do not agree within 5% of those obtained from the primary calibration standard, refer to the manufacturer's instructions and adjust the calibration.

(2) The previous statements about precision rotameter cleanliness and care apply equally to the mass flow meter. In this case, there may be the addition of a battery power supply (although many of these instruments operate off a DC power supply from an AC adapter) and electronic circuitry. Ensure that the instrument has a fresh battery and that it seems to be in proper working order. If the instrument does not function properly or if the calibration cannot be adjusted into range, if adjustable, return it to the manufacturer for repair and calibration.

f. Miscellaneous Calibration Concerns.

(1) The ball-type flow meters and rotameters built into most air samplers are primarily intended to serve only as flow indicators and are therefore of low accuracy. They are not to be used for pump calibration.

(2) Consider any potential back pressure or sample distribution issues if you are calibrating or sampling using Luer adapters for cassettes.

(3) For calibration of pumps for sampling trains for cyclones, there are concerns with leakage or other technical issues when using the calibration/bell jar procedure.

(a) If a calibration jar is used, ensure that there is no leakage. Also, do not use too large a calibration jar. If the jar is very large, a dead volume in the jar can affect the rise/fall of the piston on dry flow calibrators causing the readings to be erroneously low.

(b) Otherwise, use the OSHA recommended jarless cyclone calibration procedure.

(4) For calibration of pumps for sampling trains for open face cassettes, there are concerns with leakage when using the calibration/bell jar procedure.

(a) OSHA recommends calibrating with the cassette closed faced as opposed to using a calibration jar.

(b) If a calibration jar is used, ensure that there is no leakage. Also, do not use too large a calibration jar. If the jar is very large, a dead volume in the jar can affect the rise/fall of the piston on dry flow calibrators causing the readings to be erroneously low.

(5) Calibration flowrates should be reported at most to three significant figures, even if an electronic readout shows more. (e.g. A flowrate reading of 1.008 liters per minute should be reported as 1.01 liters per minute.)

## 8. Field Calibration of Noise Measuring Instruments

a. Sound Level Meters (SLM). Calibrate SLMs using the appropriate acoustical calibrator before and after each use. Calibrate in accordance with the manufacturer's instructions. Record all the required calibration data on NMCPHC Form 5100/17. The SLM should be calibrated in the same temperature, pressure, and relative humidity environment as that in which it is to be used.

(1) Calibrate the SLM on the "A" and "C" networks before and after each use with the companion calibrator at 1,000 Hertz. Quarterly, check the "A" and "C" networks at all frequencies provided on the calibrator for reading within the proper tolerance as found in the charts contained in ANSI S1.4-1983 (R1994) - Table IV. Follow the manufacturer's instructions, especially in relation to altitude/atmospheric pressure correction. Use only the acoustical calibrator designed to be used with your meter. The use of brand X calibrator and brand Y meter, even if the microphones are physically the same size, should be avoided unless specifically recommended by the manufacturer. Variations in calibrator chamber volume can cause errors in calibration, unless correction factors are applied.

(2) If the meter has a mechanical movement as opposed to a digital display, the meter should be calibrated at the same angle of tilt as it is to be used. If this is not possible, check to make sure that the meter readings at the vertical and horizontal angles are within 0.5 decibel (dB) of each other.

b. Noise Dosimeters. Noise dosimeters must be calibrated using an acoustical calibrator before and after each use with the results being recorded. Calibration will be performed in accordance with the manufacturer's instructions. Readouts of the dosimetry results should be done before post-calibration of the dosimeter is performed. Record required calibration data on NMCPHC Form 5100/18.

c. Acoustical calibration. All sound level meters, noise dosimeters, octave band analyzers, and acoustical calibrators used to calibrate sound level meters or noise dosimeters, shall be electro-acoustically calibrated and certified annually according to the applicable ANSI standard by the NMCPHC Calibration Laboratory or comparable calibration service.

## 9. Field Calibration Checks of Detector Tube Pumps

a. Leakage Test.

(1) Each day prior to use, perform a leakage test on the pump in accordance with the manufacturer's instructions, to minimize erroneous readings due to air leaks around the seals, or pinholes in bellows type pumps. This is usually done by inserting an unopened detector tube into the pump tube holder and withdrawing locking the piston in the outer position, or fully squeezing the bellows. The vacuum generated should hold for the minimum time specified by the manufacturer.

(2) If leakage cannot be repaired in the field, do not use the pump. Repair or replace the pump as necessary.

(3) Record that the leakage test was made on NMCPHC Form 5100/15 in the comment section.

b. Calibration Check. Check the flowrate of the detector tube pump for proper stroke volume measurement at least quarterly. For multiple orifice pumps check the flow for all orifices.

(1) Connect the detector tube pump directly to the bubble meter with suitable adapters and a detector tube.

(2) Wet the inside of the 100 ml bubble meter with a soap solution. Dip the end of the bubble meter into the soap solution to initiate the bubble and pull the piston or squeeze the bellows several times to ensure the bubble will travel at least 100 ml before bursting. Initiate a new bubble and gently pull the piston or release the bellows until the bubble reaches the zero graduation line. At this point, for a piston pump, push the piston in all the way while watching the bubble. If the bubble remains stationary, pull the piston handle all the way out and lock into position. If the bubble in the tube goes down when the piston is pushed in, the check valve is leaking and the pump needs to be repaired. When using a bellows pump, when the bubble reaches the zero graduation line, squeeze the bellows as much as possible and release. As above, if the bubble goes down when squeezing the bellows, repair the pump.

(3) Allow 4 minutes for the pump to draw the full amount of air and note where the bubble stops. The volume must be within 5 percent of the manufacturer's specified volume for a full stroke (usually 100 ml).

(4) Also check the volume for 50 cc (1/2 pump stroke) and 25 cc (1/4 pump stroke), if applicable. Plus or minus 5 percent error is permissible. If error is greater than 5 percent, repair and recalibrate the pump before using.

(5) Record the calibration information required in the calibration log.

## 10. Field Calibration of Combustible Gas Meters and Toxic Gas Meters

a. Combustible gas meters are calibrated according to manufacturer instructions, typically before and after use. It is important to note that a “bump test” is a functional check of the alarms on the meter and does NOT provide a verification of the accuracy of the concentration readings. Some meters will have an interval (span of days) that calibration is maintained within thus requiring only that the bump test be performed before and after use. Anytime the bump test does not pass calibration must be performed.

b. When measuring explosive levels in atmospheres where the identity of the explosive contaminant is known, calibrate the combustible gas meter using the manufacturer’s recommended calibration gas and use the manufacturer's response curves/conversion charts for that explosive contaminant.

c. When measuring explosive levels in atmospheres where the identity of the explosive contaminant is not known or no manufacturer’s response curve is available for the explosive contaminant, many manufacturers consider it best to calibrate the combustible gas meter with either propane or pentane (consult the manufacture of the particular meter), since they fall in the middle of the relative sensitivity/response chart, and most gases and vapors will respond within a reasonable safety margin. (Due to the effect of some substances (e.g., silicones, halogenated hydrocarbons) to reduce the sensitivity or poison the combustible sensors or filaments of the meter, it is recommended that methane also be used to check the meter for loss of sensitivity to methane. This check is not a recalibration but is to be done in addition to the propane or pentane calibration.)

## 11. Field Calibration of Oxygen Meters

a. Following manufacturer's guidelines, calibrate the oxygen meter in air known to contain 20.9% oxygen and outside of the space to be tested.

b. Changes of altitude or atmospheric pressure can affect the performance of some oxygen meters, requiring that the oxygen meter be calibrated for existing conditions.

## 12. Field Calibration of Direct Reading Dust Monitors

Calibrate dust monitors following manufacturer's guidelines.

## 13. Field Calibration of Air Velocity Meters

Typically, no field calibration is necessary. However, the meter should be qualitatively checked to ensure that it is in good working condition following manufacturer’s instructions.

## 14. Out of Tolerance Equipment

a. Equipment that fails to field calibrate within the manufacturer's specifications, fails to hold calibration, or is damaged in such a way as to render the results unreliable will be clearly identified and removed from service. Do not return the equipment to service until it has been repaired and recalibrated by a qualified calibration laboratory.

b. Equipment that has not been maintained/calibrated within the interval specified in this document will be identified and removed from service.

## 15. Equipment Lifecycles

Appendix 8-C is the United States Navy Bureau of Medicine and Surgery Equipment Management Manual (NAVMED P-5132) (Reference 8-2) Decision Chart for Equipment and Repair to determine when to replace IH equipment.

## 16. Recordkeeping

a. Comprehensive and accurate records are necessary to document the calibration of industrial hygiene sampling equipment.

b. Periodic and field calibration is documented on sampling forms as appropriate.

c. Periodic calibration records shall contain, as a minimum:
   (1) Item description, including manufacturer and model number;
   (2) Item serial number;
   (3) Dates of calibration;
   (4) Who performed the calibration; and
   (5) In the case of scheduled periodic calibration, when the next calibration is due.

d. Additional calibration records may be in the form of a log, card file, or other appropriate method which provides the necessary documentation.

## 17. References

8-1. NAVSEA Publication OD 45845/NAVAIR 17-35MTL-1, Metrology Requirements List (METRL).

8-2. BUMED. NAVMED P-5132, Equipment Management Manual (2008).

8-3. OSHA Technical Manual. OTM-Appendix F, Calibration.

# Appendix 8-A – List of Sound Level and Audiometric Equipment Serviced

a. Sound Level Meters, Type 1
   (1) Bruel & Kjaer Model Nos. 2230, 2232, 2235, 2236, 2238, 2240, 2250 & 2260
   (2) CEL Model Nos. 266/3, 275/3, 414/3, 493/3, 553, 573 & 593
   (3) General Radio Model Nos. 1982 & 1988
   (4) General Radio Octave Band Filters Model Nos. 1625 & 1982
   (5) Larson Davis Model Nos. 800B, 824, 831 & LX1
   (6) Metrosonics Model Chameleon
   (7) Quest Model Nos. 155, 1700, 1800, 1900 & SoundPro SE/DL/DLX/RTA
   (8) 3M/Quest Octave Band Filters Model Nos. OB50, OB100, OB145 & OB300
   (9) Sper Scientific Model Nos. 840029, 840013 & 840031
b. Sound Level Meters, Type 2
   (1) Bruel & Kjaer Model No. 732
   (2) CEL Model Nos. 231, 240, 242, 254, 275, 282, 292, 328/3 & 383/3
   (3) Extech Model Nos. 407730, 407732, 407736 & 407764
   (4) General Radio Model No. 1565B
   (5) MSA Model No. 695090
   (6) 3M/Quest Model Nos. 210, 211, 211F/S, 214, 215, 228, 2100, 2200, 2400, 2500, 2700, 2800, 2900, SD-200 & SE-402, SE-40215
   (7) Simpson Model Nos. 884 & 886
   (8) Sper Scientific Model No. 840013
   (9) Larson Davis Model No. LX2
c. Dosimeters
   (1) Ametek/Dupont Model Nos. MK1, MK2 & MK3 CEL Model Nos. 281, 320, 328, 360, 420, 460 & 593
   (2) General Radio Model No. 1954 (Note: need indicator to calibrate; recommend surveying unit due to age)
   (3) Larson Davis Model Nos. 703, 705, 706 & 710
   (4) Metrosonics Model Nos. db307, db308, db3070, db3080, db3088 & db3100
   (5) Quest Model Nos. M7B, M14, M15, M27, M28, Q100, Q-200, Q220P, Q300, Q400,
   (6) Q500, EDGE & Noise Pro DL/DLX
d. Calibrators
   (1) Bruel & Kjaer Model Nos. 4220, 4230, 4231 & CAL-73
   (2) Casella Model No. 110/2
   (3) CEL Model Nos. 282 & 284
   (4) Dupont Model Nos. AC1 & AC94
   (5) General Radio Model Nos. 1562A, 1986 & 1987
   (6) Larson Davis Model Nos. 150, 200 & 250
   (7) Metrosonics Model Nos. CL302, CL304 & CL305
   (8) MSA Model No. 695094
   (9) 3M/Quest Mod Nos. AC-300, CA12, CA12A, CA12B, CA12M, CA15B, CA22, CA32, QC10 & QC20

(10) Simpson Model No. 890

e. Audiometers

(1) Ambco Model Nos. A-15 & 2500
(2) Beltone Model Nos. 119 & 120
(3) Benson Medical Instruments Model Nos. CCA-200 and CCA-200 mini with simulator BAS-200 or ME-500
(4) Grason-Stadler, Inc. Model No. GSI-17
(5) Maico Model Nos. MA800, MA1000, MA25, MA27, MA39, MA40, MA41, MA42 & MA728
(6) Monitor Model No. MI-5000
(7) Tremetrics/Tracor Model Nos. RA300, RA400, RA500 & HT Wizard
(8) Welch Allen AM-232

# Appendix 8-B – Table 8-1.* Laboratory and Field Calibration Intervals and Actions

| Instrument Type | Laboratory Calibration Interval(Years) | Field Check or Field Calibration |
|---|---|---|
| Battery Chargers<br>Single or multiunit chargers | ** | None |
| Bioaerosol Samplers and high volume pump | ** | Before and after use |
| Combustible Gas Indicators | *** | *** |
| with oxygen indicator | *** | *** |
| with oxygen and toxic gas indicators | *** | *** |
| Dust/Aerosol Monitors | 1 | *** |
| Flow meters<br>Precision Rotameters | ** | Quarterly |
| Electronic Bubble Meters | ** | Annual |
| Electronic Dry Flow Meters | ** | Annual<br>Quarterly leak check |
| Kurz Mass Flow Meter | ** | Quarterly |
| Heat Stress Monitors | 3 | Operational check before and after use |
| Indoor Air Monitors<br>Temperature and Humidity with $CO_2$ and/or toxic gas sensor(s) | 1 | Semi-annual humidity check if saturated salt bottles provided<br>Zero and span cal before and after use |

**NOTE:** * Table 8-1 continues on the next page. This table lists general equipment laboratory and field calibration intervals. If conflicts exist with individual manufacturer's requirements, the manufacturer's requirements take precedence.
** Inspect/repair as necessary
***According to manufacturer's instruction

**Table 8-1.* Laboratory and Field Calibration Intervals and Actions (continued)**

| Instrument Type | Laboratory Calibration Interval(Years) | Field Check or Field Calibration |
|---|---|---|
| Light Meters | 1 | Zero check |
| Non-Ionizing Radiation Meters | 1 | None |
| Pump, Detector Tube | ** | Leak check prior to use |
| Pumps, High Volume | ** | Before and after use |
| Pumps, Personal | ** | Before and after use |
| Sound Measuring Instruments (e.g., sound level meters, microphones, 1/3, 1/2, and 1/1 octave filters, personal noise dosimeters) | 1 | Before and after use |
| Sound Level Calibrators | | |
| Indoor Air Monitors<br><br>In general<br><br>Mercury Vapor Meter | <br><br>**<br><br>*** | <br><br>***<br><br>Zero check before use |
| Air Velocity Meters and Flow Hoods | 1*** | Zero check before use |
| Miscellaneous<br>Portacount Respirator Fit Tester - Quantitative Respirator Fit Test Apparatus | *** | *** |

**NOTE**: * Table 8-1 lists general equipment laboratory and field calibration intervals. If conflicts exist with individual manufacturer's requirements, the manufacturer's requirements take precedence.
** Inspect/repair as necessary
***According to manufacturer's instruction

# Appendix 8-C – BUMED. NAVMED P-5132 Equipment Management Manual, Decision Chart for Equipment Repair and Replacement 3 Jan 2008