Chapter 8 – Equipment Maintenance and Calibration

1. General

a. The maintenance and calibration of industrial hygiene (IH) equipment is critical to ensure 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' exposures 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. This chapter does not apply to RADIAC equipment.

3. Responsibilities

Each command owning IH equipment must be responsible for the correct operation, maintenance and calibration of that equipment. The Defense Occupational and Environmental Health Readiness System-Industrial Hygiene (DOEHRS-IH) is the primary method of inventorying, maintaining, and recording calibration of IH equipment. All IH equipment must be entered into the DOEHRS-IH program office responsible for that equipment. Retention of calibration certificates and other records is covered in paragraph 16. For more information about DOEHRS-IH consult reference 8-1.

4. Calibration, Checks and Maintenance

a. General. Most types of IH 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, 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 are 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. Calibration records should be maintained within DOEHRS-IH. Retention of calibration certificates and other records is covered in paragraph 16. For more information about DOEHRS-IH consult reference 8-1.

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 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 used to collect the sample (e.g., glass fiber filter preceding impinger) 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. 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 8-2.

   (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 performed by a NIST traceable calibration facility on an annual basis.
      (c) Enter calibration data into DOEHRS-IH. Retention of calibration certificates and other records is covered in paragraph 16. For more information about DOEHRS-IH consult reference 8-1.

b. Electronic Soap Bubble Flow Calibrator (Bubble Meter) Method. 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. Bubble Burette Method. This is an emergency method to be used when no other calibration equipment is currently NIST calibrated. It may be used to calibrate dry piston calibrators when circumstances have allowed NIST calibration to lapse.

(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 tubing connections.

(5) Momentarily submerge the opening of the burette to capture a film of soap.

(6) Draw two or three bubbles up the burette 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 dry piston calibrator. 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.

d. 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 calibrated by a calibration laboratory as explained in paragraph 7.a.(2)(b) above.
   (2) Enter calibration data into DOEHRS-IH. Retention of calibration certificates and other records is covered in paragraph 16. For more information about DOEHRS-IH consult reference 8-1.

e. 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) Cassette adapters (e.g., plastic or metal Luer taper adapters) should not be used. Luer adapters in front of a filter in a calibration train can potentially generate significant back pressure for which some pressure regulating pumps may not be able to compensate, resulting in inaccurate results. Luer adapters behind filters can affect sample distribution across an open-face cassette, and some Luer adapters are long enough that they may even make contact with the backup pad in the cassette. For this reason their use is not recommended. There are commercially available filter cassette holders with integrated connectors that do not have an adverse effect on back pressure.
   (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 or the BIOS Dry-Cal jarless method.

(4) The appropriate way to calibrate an open-face cassette is to use the cover section which comes with the cassette and attach the tubing directly from the electronic flow calibrator to the inlet port on the cassette cover. Be certain there are no leaks and do not use a Luer adapter. This set-up will provide the least amount of flow resistance and represent the open-face conditions while actually sampling. Perform the pump calibration at the pressure (altitude) and temperature where sampling is to be conducted. If this is not possible, consult the operating manual for the sampling pump to determine if the air volume needs to be adjusted for temperature and pressure.

(5) Calibration flowrates should be reported at most to three significant figures, even if an electronic readout shows more (e.g. , 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. Enter calibration data into DOEHRS-IH. Retention of calibration certificates and other records is covered in paragraph 16. For more information about DOEHRS-IH consult reference 8-1.

(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. Enter calibration data into DOEHRS-IH.

Retention of calibration certificates and other records is covered in paragraph 16. For more information about DOEHRS-IH consult reference 8-1.

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. Enter calibration data into DOEHRS-IH. Retention of calibration certificates and other records is covered in paragraph 16. For more information about DOEHRS-IH consult reference 8-1.

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. Enter calibration data into DOEHRS-IH. Retention of calibration certificates and other records is covered in paragraph 16. For more information about DOEHRS-IH consult reference 8-1.

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. Enter calibration data into DOEHRS-IH. Retention of calibration certificates and other records is covered in paragraph 16. For more information about DOEHRS-IH consult reference 8-1.

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 Decision Chart for Equipment Repair or Replacement from the BUMED Equipment Management Manual (NAVMED P-5132) (reference 8-3) which can be used to determine when to replace IH equipment.

16. Recordkeeping

a. Comprehensive and accurate records are necessary to document the calibration of IH sampling equipment.
   (1) Per reference 8-4, sampling results, the collection methodology (sampling plan), a description of the analytical and mathematical methods used, and a summary of other background data relevant to interpretation of the results obtained, are retained for at least thirty (30) years;
   (2) Calibration records are considered part of background data relevant to interpretation of results, as the calibration ensures that the equipment was working and measuring correctly at the time of sampling. Calibration records must be kept, either hard copy or digitally, for a period of 30 years.

b. Periodic and field calibration is documented on sampling forms as appropriate. Enter calibration data into DOEHRS-IH. For more information about DOEHRS-IH consult reference 8-1. 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.

c. 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. NMCPHC DOEHRS-IH Page.

8-2. OSHA Technical Manual. OTM-Appendix F, Calibration.

8-3. BUMED. NAVMED P-5132, Equipment Management Manual (31 Dec 2015).

8-4. OSHA 29 CFR 1910.1020. Access to employee exposure and medical records.

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 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	1	
Electronic Bubble Meters	**	Annual
Electronic Dry Flow Meters	**	Annual Quarterly leak check
Kurz Mass Flow Meter	**	Quarterly
Heat Stress Monitors	3	Operational check before and after use
Indoor Air Monitors Temperature and Humidity with CO_2 and/or toxic gas sensor(s)	1	Semi-annual humidity check if saturated salt bottles provided Zero and span cal before and after use

* 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	1	
Indoor Air Monitors In general Mercury Vapor Meter	 ** ***	 *** Zero check before use
Air Velocity Meters and Flow Hoods	1***	Zero check before use
Miscellaneous Portacount Respirator Fit Tester - Quantitative Respirator Fit Test Apparatus	***	***

* 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 (31 Dec 2015)