UNITED STATES · ENVIRONMENTAL PROTECTION AGENCY ·

Task Analysis of State and
Local Air Pollution Control Agencies and
Development of Staffing Guidelines

VOLUME E

Detailed Task Data, and Staffing Guidance AIR MONITORING AND METEOROLOGICAL SUPPORT

ENVIRONMENTAL PROTECTION AGENCY
Manpower Development Staff Office of Air Programs
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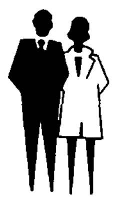

Detailed Task Data, and Staffing Guidance
AIR MONITORING AND METEOROLOGICAL SUPPORT

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AIR MONITORING AND METEOROLOGICAL SUPPORT

The task data and staffing guidance presented in this volume cover a group of tasks relevant to the monitoring of ambient air quality conditions and the effects of meteorological conditions on air quality. The tasks described here are performed by Equipment Technicians, Chemists, Meteorologists, and Meteorological Technicians. The tasks included in this volume are listed below:

Operation and Maintenance of the
Flame Ionization Hydrocarbon Analyzer

Task Overview

The hydrocarbon analyzer described herein utilizes the flame ionization method of detection. The sensor is a burner where a regulated flow of sample gas passes through a flame sustained by regulated flows of fuel gas and air. Within the flame, the hydrocarbon components of the sample stream undergo an ionization that produces electrons and positive ions. Polarized electrodes collect these ions, causing current to flow through an electronic measuring circuit. The ionization current is proportional to the rate at which carbon atoms enter the burner and is, therefore, a measure of the concentration of hydrocarbons in the original sample. The analyzer provides direct readout on a front-panel meter and a selectable output for an accessory recorder. Briefly, the steps required for operation and maintenance of the flame ionization hydrocarbon analyzer include:

1. Installation of the instrument.
2. Prestart-up and start-up of the instrument.
3. Routine operation of the device.
4. Servicing of the instrument.
5. Instrument calibration.
6. Troubleshooting for sources of malfunctions.
7. Interpretation of instrument outputs.

Occupational Category: Equipment Technician (Senior)

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of a hydrocarbon analyzer (the Beckman Model 400). The following skill and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to install the instrument, including:

    a. Connecting flowmeter to BY-PASS outlet and measure gas flow rate.

    b. Cleaning fuel, air, and sample lines and regulators using nitrogen or helium along with a torch to heat the tubing to at least $300^{\circ}C$.

    c. Purging external fuel, air, and sample lines.

    d. Inserting circuit board into its socket without damage to socket or board.

2. Ability to start up and operate the instrument, including:

    a. Checking for contamination in air and fuel systems.

    b. Reading table of ranges for various combinations of settings on RANGE MULTIPLIER switch and SPAN control.

3. Ability to service the instrument, including:

    a. Disconnecting amplifier input cable from burner without damage to the field-effect transistor.

    b. Comparing obtained curve to standard curve to make drift check.

    c. Removing flow system from the unit.

    d. Checking battery voltage.

4. Ability to troubleshoot the instrument, including:

    a. Purging gas lines.

    b. Cleaning fuel and air supply lines and regulators using nitrogen or helium and heat.

    c. Cleaning burner with appropriate solvents.

    d. Identifying malfunctioning check valve in sample pump.

5. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.

6. Ability to read and interpret data from a table, psychometric chart, or a nomograph.

7. Ability to handle pressurized gas without endangering personnel or equipment.

8. Ability to coordinate adjustment screw or hand knob movements with meter or chart recorder reading to quickly achieve and maintain the desired reading.

9. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

10. Ability to detect leaks in hose, tubing, and piping connectors carrying liquids, gases, or vacuum using simple leak detection aids as appropriate.

11. Ability to disconnect and connect standard hose tubing and piping connectors without injury to threads and achieving leakproof connections. This includes the use of thread compound and teflon tape as appropriate.

12. Ability to disconnect and connect standard electrical connectors. This includes identifying leads to facilitate correct connection and achieving tight connections without damage to the leads or terminals.

13. Ability to correctly interpret function diagrams, wiring and tubing diagrams, simple electrical schematics, and troubleshooting charts.

14. Ability to interpret engineering drawings and piping diagrams.

15. Ability to use electrical test instruments such as

    a. AC/DC voltmeter

    b. Ammeter

    c. Ohmmeter

    to achieve accurate circuit measurements without damage to the test instruments.

16. Ability to detect pinched, ruptured or otherwise defective tubing and incorrect tubing connection.

17. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

Knowledge Requirements

1. Knowledge of procedures for installing the instrument, including:

   a. How to protect instrument from vibration and temperature extremes.

   b. Criteria for correct sample gas supply pressure.

   c. Procedure for making gas connections.

   d. Knowledge that exhaust line must slant down at least 10^{o} from horizontal to allow moisture to drain.

   e. Appropriate gas pressures.

   f. Precautionary measures necessary when working with the fuel gas (hydrogen).

2. Knowledge of procedures for starting up and operating the instrument including:

   a. Appropriate external gas pressure requirements.

   b. Procedure for checking fuel and air systems for contaminants.

   c. Techniques to minimize meter drift caused by hydrocarbon contaminants in the fuel and air systems or supplies.

   d. Procedure for calibrating of instrument.

   e. Proper standard gases to use for instrument calibration.

   f. Proper environmental conditions for operation (e.g., air temperature and humidity).

g. Exact hydrocarbon content of the standard gases used for calibration.

h. Procedure for routine operation.

i. Differential instrument response to different hydrocarbons.

3. Knowledge of the procedures for servicing and troubleshooting the instrument, including:

   a. Procedure for checkout of the system.

   b. Procedure for servicing flow system and burner.

   c. Malfunction symptom patterns.

   d. Safe handling techniques for acetone and methyl ethyl ketone.

4. Knowledge of the function and location of each operation and adjustment control on the instrument.

5. Knowledge of the name and location of the various component parts of the instrument.

6. Knowledge of the operating parameters for the instrument, including:

   a. Time for initiating sample collection.

   b. Sampling duration.

   c. Flow rate.

7. Knowledge of the tools and materials required for maintaining the instrument.

8. Knowledge of set-up training and spare parts supply programs.

References

1. Beckman Instruments, Inc. Beckman Model 400 hydrocarbon analyzer. Fullerton, California: Author, April 1970.

Special Staffing Guidance

Because of the relatively extensive skills and knowledge requirements, this task should be assigned to a senior level Equipment Technician.

Operation and Maintenance of the Infrared Analyzer

Task Overview

The infrared analyzer continuously monitors a selected component in a gas stream so that small changes in the component concentration can be detected before their cumulative effect would be revealed by laboratory tests. The gas to be monitored is continuously drawn through a sample cell in the device, while a known gas is held in a comparison cell. Identical infrared beams are alternately directed through the two cells allowing the comparison of the absorption of infrared energy by the two gases. As long as the energy at a detector located at the end of the gas sample cells is equal in both beams, a properly aligned instrument will read zero. Briefly, the steps required for operation and maintenance of the infrared analyzer include:

1. Installation and initial adjustment of the instrument.
2. Routine maintenance and periodic adjustment.
3. Alignment and calibration of the analyzer.

Occupational Category: Equipment Technician (Senior)

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of an infrared analyzer (the MSA Model 300). The following skill and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to install, align, and maintain the instrument, including:
   a. Introducing zero and span gas into the instrument at equal flow rate and pressure.

b. Adjusting motor position using motor position adjustment to obtain meter reading as close to zero as possible.

c. Tightening motor mounting screws without changing motor adjustment.

d. Cleaning gold-plated surface of cell with lint-free cloth and soft wooden rod without damaging cell and window located at the end of the cell (using isopropyl alcohol or acetone).

2. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.

3. Ability to handle pressurized gas without endangering personnel or equipment.

4. Ability to coordinate adjustment screw or hand knob movements with meter or chart recorder reading to quickly achieve and maintain the desired reading.

5. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

6. Ability to detect leaks in hose, tubing, and piping connectors carrying liquids, gases, or vacuum using simple leak detection aids as appropriate.

7. Ability to disconnect and connect standard hose tubing and piping connectors without injury to threads and achieving leakproof connections. This includes the use of thread compound and teflon tape as appropriate.

8. Ability to disconnect and connect standard electrical connectors. This includes identifying leads to facilitate correct connection and achieving tight connections without damage to the leads or terminals.

9. Ability to use electrical test instruments such as:

    a. AC/DC voltmeter

    b. Ammeter

    c. Ohmmeter

   to achieve accurate circuit measurements without damage to the test instrument.

10. Ability to detect pinched, ruptured or otherwise defective tubing and incorrect tubing connection.

11. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

<u>Knowledge Requirements</u>

1. Knowledge of the installation and initial adjustment procedures for the instrument including:

    a. How to protect instrument from vibration, sun, rain, heat, and cold when installed.

    b. The procedure to follow for connecting analyzer to flow system.

    c. The proper calibration procedure.

    d. Span and zero gas characteristics and the procedure for introducing them to the sampling flow of the instrument.

2. Knowledge of routine maintenance and periodic adjustment procedures for the instrument including:

    a. The procedure for making zero adjustment.

    b. The span and zero gas characteristic and the procedure for introducing them to the sampling flow of the instrument.

c. Procedure for checking and adjusting oscillator voltage.

d. Procedure for measuring and adjusting temperature control.

e. Procedure for replacing amplifier.

f. Procedure for removing detector and cleaning sample cell.

g. Procedure for zeroing the instrument.

h. Knowledge of safe handling techniques for isopropyl alcohol and acetone.

3. Knowledge of the procedure for alignment and calibration of the instrument, including:

   a. Procedure for adjustment of the oscillator.

   b. Procedure for zeroing amplifier.

   c. Procedure for balancing optical signal.

   d. Procedure for rough calibration of the instrument.

   e. Procedure for amplifier balance adjustment.

   f. Span and zero gas characteristics and the procedure for introducing them to the sampling flow of the instrument.

   g. Procedure for making final zero and span adjustments.

   h. Procedure for making zero meter adjustment.

4. Knowledge of the preventative maintenance procedure and the malfunction symptom patterns of the instrument and their causes.

5. Knowledge of the function and location of each operation and adjustment control on the instrument.

6. Knowledge of the name and location of the various component parts of the instrument.

7. Knowledge of the operating parameters for the instrument, including:

    a. Time for initiating sample collection.

    b. Sampling duration.

    c. Flow rate.

8. Knowledge of the tools and materials required for maintaining the instrument.

References

1. Mine Safety Appliances Company. Lira infrared analyzer, model 300. Theory, operation, service. Pittsburgh: Author.

Special Staffing Guidance

Because of the relatively large number of skills and knowledge which must be acquired in order to maintain this instrument, it is suggested that a senior level Equipment Technician be assigned to the task.

Operation and Maintenance of the Coulometric Titration Analyzers for SO_2, NO, NO_2, or Oxidants

Task Overview

The coulometric titration type analyzer basically performs a dynamic iodimetric titration to continuously measure the concentration of pollutant in the air sample aspirated through the analyzer. For NO, NO_2, and oxidants, the incoming sample is passed into a detector cell containing a carbon anode and a platinum cathode, both immersed in a buffered-halide/potassium-iodide electrolyte. As ambient air is aspirated through the electrolyte, the pollutant reacts chemically with the iodide present in the electrolyte to form molecular iodine. This iodine is transported to the cathode where, acting as a depolarizer by undergoing reduction, it allows an electrical current to flow between the anode and cathode. The NO analyzer is basically the same as the NO_2 analyzer except that the incoming sample first passes through a selective scrubber for removal of interferents. Sample NO is then quantitatively converted into NO_2 by gas-phase oxidation with molecular ozone produced within the analyzer.

The SO_2 analyzer physically differs from the others due only to the presence of a third, or reference, electrode. The sulfur dioxide component of an atmospheric sample introduced to the detector cell undergoes hydrolysis in the electrolyte. The hydrolysis product acts as a chemical reductant to the steady-state concentration of iodine existing in the cell, and a decrease in the steady-state iodine concentration ensues. This effect causes an electrochemical unbalance in the cell. A fraction of the applied current, related to the electrochemical unbalance, is forced to flow through the reference electrode as an alternate current path.

In all cases current flow is related quantitatively to the concentration of the pollutant in the sample and is amplified to drive meter and an accessory potentiometric recorder if desired.

Briefly the steps required for operation and maintenance of the coulometric titration analyzers include:

1. Installation and preoperational check.
2. Preparation of instrument.
3. Operation of instrument.
4. Checkout of instrument.
5. Troubleshooting for sources of malfunctions.

Occupational Category: Equipment Technician

Task Description

Examples of the procedures for operation and maintenance of the SO_2 analyzer are presented in References 1 and 2 (Beckman Model 906), the NO analyzer in Reference 3 (Beckman Model 909), the NO_2 analyzer in Reference 4 (Beckman Model 910), and the oxidants analyzer in Reference 5 (Beckman Model 908). The following skill and knowledge requirements are representative of these categories of tasks.

Skill Requirements

1. Ability to install the instrument including:
   a. Detecting instrument damage caused by shipping, including hairline cracks in glass parts.
   b. Making tubing connections with teflon or polypropylene tubing.
   c. Connecting standard electrical connectors.
   d. Making zero meter adjustments with zero adjust screw.
   e. Setting automatic water addition timer (SO_2 analyzer only).
   f. Matching the potentiometric output of the instrument to the recorders.

2. Ability to prepare and operate the instrument including:

   a. Removing bubbles from cathode, anode, and glass tubing by tapping the glass tubing where bubble is evident.

   b. Replacing cathode assembly to a snug, airtight fit.

   c. Flushing inlet capillary tubing with distilled water using instrument suction to draw water through tubing after it is disconnected.

3. Ability to perform routine maintenance and servicing of the instrument including:

   a. Cleaning parts with distilled water, acid-duchromate solution, alcohol, and aqua regia.

   b. Recharging the selective scrubber with the correct material givep the pollutant being analyzed.

   c. Positioning capillary tube so that tip is 1/8 inch from wall of SO_2 reaction tube. (SO_2 analyzer).

   d. Rolling glass wool into loose balls of appropriate size to fit into charcoal column. (SO_2 analyzer).

   e. Adjusting rotameter to correction factor printed on sticker located above Inlet Selector Switch. (SO_2 analyzer).

   f. Determining stable baseline with no drift obtained.

   g. Preparing replacement capillary tubes to maintain specified flow characteristics.

4. Ability to troubleshoot the instrument including:

   a. Disconnecting and connecting standard electrical connectors.

   b. Detecting:

      1) Crystallization at bottom end of teflon capillary inlet tube, i.e., gas-liquid interface, plugging of cell exhaust system and lines leading to water trap.

2) Dirt in capillary tubing or circulating in the cell.

3) Yellow electrolyte due to platinum cathode wire broken, reduced flow in cell, or depleted anode.

c. Connecting external flowmeter to the cell inlet.

d. Detecting:

1) Electrically open meter.

2) Defective amplifier.

3) Cathode lead shorted to anode lead.

4) Seized meter needle.

5) Depleted O_3 scrubber. (NO analyzer only)

6) Contaminated electrolyte.

7) Solid particles in teflon capillary tubing.

8) Loose electrodes.

9) Faulty electrodes.

10) Damaged thermistor.

5. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.

6. Ability to coordinate adjustment screw or hand knob movements with meter or chart recorder reading to quickly achieve and maintain the desired reading.

7. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

8. Ability to detect leaks in hose, tubing, and piping connectors carrying liquids, gases, or vacuum using simple leak detection aids as appropriate.

9. Ability to disconnect and connect standard hose tubing and piping connectors without injury to threads and achieving leakproof connections. This includes the use of thread compound and teflon tape as appropriate.

10. Ability to disconnect and connect standard electrical connectors. This includes identifying leads to facilitate correct connection and achieving tight connections without damage to the leads or terminals.

11. Ability to install measured amounts of reagents and distilled water in the analyzers without losing any and without contaminating them or the analyzer.

12. Ability to correctly interpret function diagrams, wiring and tubing diagrams, simple electrical schematics and trouble-shooting charts.

13. Ability to use electrical test instruments such as:

    a. AC/DC Voltmeter

    b. Ammeter

    c. Ohmmeter

    to achieve accurate circuit measurements without damage to the test instruments.

14. Ability to detect pinched, ruptured or otherwise defective tubing and incorrect tubing connection.

15. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

16. Ability to read the recorder chart interpreting the position and slope of the tracing in terms of the variables represented on the ordinate and abscissa (i.e., the pollutant concentration over time or the strength of X-ray defraction as a function of beam angle).

17. Ability to service and operate a chart recorder, including replacing chart roll, resupplying ink (if required), and adjusting the baseline (zero) point, line density, chart speed, and sensitivity range.

Knowledge Requirements

1. Knowledge of the procedure for installing the instrument *including:*

    a. Setting up the analyzer such that it will be protected from vibration and temperature extremes.

    b. Setting the automatic water addition timer.

    c. Attaching a chart recorder (if used).

2. Knowledge of the procedure for preparation and operation of the instrument including:

    a. The procedure for charging detector with electrolyte and filling reservoir with distilled water.

    b. Knowledge that extreme care must be utilized to avoid contamination of the water reservoir, water, and electrolyte.

    c. The procedure for starting and operating instrument.

    d. Procedure for checking instrument drift and change in rotameter settings. (SO_2 Analyzer).

3. Knowledge of the routine maintenance procedures for the instrument including:

    a. Procedure for cleaning rotameter. (SO_2 Analyzer)

    b. Knowledge of safe handling techniques for acid-dichromate and aqua regia.

    c. Procedure for cleaning inlet selector switch.

   d. Procedure for cleaning sample regulator.
   e. Procedure for replacing capillary inlet tubing.
   f. Procedure for replacing scrubber.

4. Knowledge of the service procedures for the instrument including:
   a. Replacing electrolyte.
   b. Filling water reservoir.
   c. Adding water to cell.
   d. Flushing exhaust outlet of detector cell.
   e. Adjusting operational parameters.
   f. Cleaning detector cell assembly.
   g. Removing instrument from operation.

5. Knowledge of the procedure for troubleshooting the instrument including:
   a. Procedure for checkout of electronics.
   b. Procedure for checkout of detector cell.
   c. Procedure for checkout of gas-phase flow system.
   d. Knowledge of electronic, detector cell and gas flow system malfunction patterns.

6. Knowledge of the procedures for installing appropriate reagents and reference solutions of the required concentrations and distilled water in the analyzer.

7. Knowledge of the function and location of each operating and adjustment control on the instrument.

8. Knowledge of the name and location of the various component parts of the instrument.

9. Knowledge of the following procedures for the chart recorder used in conjunction with the instrument:

    a. Installation (including impedance matching)

    b. Servicing

    c. Troubleshooting

    d. Maintenance

    e. Calibration (including zeroing the recorder)

    f. Operation

10. Knowledge of the operating parameters for the instrument, including:

    a. Time for initiating sample collection.

    b. Sampling duration

    c. Flow rate

11. Knowledge of the tools and materials required for maintaining the instrument.

References

1. Brittain, D. T., and Burmann, F. J. Operating instructions for Beckman Model 906 sulfur dioxide analyzer. U. S. Department of Health, Education, and Welfare; Public Health Service, Environmental Health Service, National Air Pollution Control Administration, August 1970.

2. Beckman Instruments, Inc. Model 906 sulfur dioxide analyzer. Fullerton, California: Author, April 1967.

3. Beckman Instruments, Inc. Beckman Model 909 NO Analyzer. Fullerton, California: Author, May 1971.

4. Beckman Instruments, Inc. Beckman Model 910 NO_2 Analyzer. Fullerton, California: Author, November 1970.

5. Beckman Instruments, Inc. Beckman Model 908 Oxidants Analyzer. Fullerton, California: Author, September 1970.

Special Staffing Guidance

1. This task involves the handling of reagents and could be assigned in some combination with the following analyzer operation and maintenance tasks, also involving the use of reagents:

    a. Operation and Maintenance of the Colorimetric Air Monitoring System (e.g., the Technicon system).

    b. Operation and Maintenance of the Sequential Sampler.

2. It is highly possible that an agency could employ several coulometric titration analyzers in order to monitor each of the various pollutants for which the instrument can be used. The same Equipment Technician should be responsible for maintenance of all these instruments and for their operation also, except where they are located in widely scattered places.

Operation and Maintenance of the Gas Chromatograph Analyzer Programmer

Task Overview

The programmer chosen as the example for this discussion, the MSA Programmer, Model 525, has ten independently programmable functions with a common time cycle base. The programming is done photoelectrically by means of a light source and ten photo-resistive cells that monitor markings on a mylar disc. An output is obtained when an opaque program mark intercepts the light normally passing through the transparent disc to its associated photocell. Programming is done with a film marking pencil and can be predetermined with a great degree of precision; changes are made with an ordinary eraser. Briefly, the operation and maintenance of the programmer consists of the following activities:

1. Programming of the device.
2. Calibration of the programmer output.
3. Routine maintenance.
4. Servicing and checking of programmer components.

Occupational Category: Equipment Technician (Senior)

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of the gas chromatograph analyzer programmer (the MSA Model 525). The following skill and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to program the instrument including:
   a. Inserting and locking disc in programmer.
   b. Zeroing recorder base line.
   c. Drawing marking pencil line the full width of appropriate valve channels for dwell time on the "ON" valve function.

2. Ability to calibrate and perform routine maintenance on the instrument including:

   a. Detecting that components are slowly drifing out of the gate.

   b. Detecting out-of-balance columns through study of the flow scheme.

3. Ability to service the instrument including:

   a. Assuring that:

      1) Photoelectric parts are free of dust.

      2) Disc and cover disc are free of undesirable markings.

      3) Program markings are uniformly darkened.

      4) Programmer turntable is protected from sunlit ambients.

   b. Detecting dark spots on fluorescent lamp.

   c. Determining if recorder has sufficient time to return to its base line before auto-zeroing begins. Also, there must be sufficient program time for zeroing to complete its action.

   d. Checking recorder gain.

   e. Insuring the auto-zero gate is functioning properly to include actuation.

   f. Identifying:

      1) Loose coupling between potentiometer and motor.

      2) Defective zero potentiometer.

      3) Loose COURSE-ZERO lock.

   g. Inspecting relay to assure it is in good operational condition.

4. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.

5. Ability to coordinate adjustment screw or hand knob movements with meter or chart recorder reading to quickly achieve and maintain the desired reading.

6. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

7. Ability to disconnect and connect standard electrical connectors. This includes identifying leads to facilitate correct connection and achieving tight connections without damage to the leads or terminals.

8. Ability to correctly interpret function diagrams, wiring and tubing diagrams, simple electrical schematics, and troubleshooting charts.

9. Ability to use electrical test instruments such as:

   a. AC/DC voltmeter

   b. Ammeter

   c. Ohmmeter

   to achieve accurate circuit measurements without damage to the test instruments.

10. Ability to solder and unsolder electrical terminals making a good electrical and mechanical connection without shorting or grounding the connection or damaging circuit components.

11. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

Knowledge Requirements

1. Knowledge of the procedure for programming, calibrating, and operating the instrument including:

   a. Knowledge of the column functions, valving functions, and stream composition.

   b. Procedure for programming unit.

   c. Knowledge of valve function channels on programmer disc.

2. Knowledge of the procedure for performing routine maintenance on the instrument including:

   a. Procedure for auto-zero centering.

   b. Procedure for attenuator grate checks.

   c. Procedure for column flow balancing.

   d. Procedure for replacing fluorescent lamp.

3. Knowledge of the procedure for servicing the instrument components including:

   a. Knowledge of the photocell wiring color code.

   b. Procedure for servicing silicon control rectifiers.

   c. Procedure for checking photocells.

   d. Procedure for checking light source.

   e. Symptoms of a defective lamp ballast:

      1) Short lamp life.

      2) Premature darkening of lamp ends.

      3) Overheating of ballast.

   f. Symptoms of a defective starter, i.e., prolonged or erratic lamp starting.

   g. Procedure for checking auto-zero.

h. Procedure for checking chart drive and chart drive time delay.

i. Procedure for checking two-stream selector.

j. Procedure for checking attentuator calibration and peak reversal.

4. Knowledge of the function and location of each operation and adjustment control on the instrument.

5. Knowledge of the name and location of the various component parts of the instrument.

6. Knowledge of the operating parameters for the instrument, including:

   a. Time for initiating sample collection.

   b. Sampling duration.

   c. Flow rate.

7. Knowledge of the tools and materials required for maintaining the instrument.

References

1. Mine Safety Appliances Company. MSA programmer, Model 525. Installation, operation, maintenance, service. Pittsburgh: Author.

Special Staffing Guidance

The senior level Equipment Technician assigned to operate and maintain this instrument should also operate and maintain the Gas Chromatograph Analyzer (see Page E-29) since these devices function as a unit.

Operation and Maintenance of the Gas Chromatograph Analyzer

Task Overview

The Gas Chromatograph Analyzer is designed to carry out vapor phase chromatographic analysis of a variety of process samples.

Analysis of the sample mixture is accomplished by passing it through one or more columns with a carrier gas such as helium. The columns contain materials which have different affinities for the various sample components, and thus cause them to separate as they pass through the columns. The sample and carrier gas mixture emerging from the columns passes through a detector which measures the concentration of the sample components which are present. In order for the measurements to be reproducible, it is necessary to maintain a constant temperature, pressure, and flow rate of the gases in the columns; it is also necessary to introduce a precisely metered volume of sample into the system; and, finally, it is necessary to maintain the sensitivity and zero adjustment of the detector constant. Briefly, the steps required for operation and maintenance of the gas chromatograph include:

1. Unpacking and installation.
2. Start-up of the instrument.
3. General maintenance.
4. Troubleshooting

Occupational Category: Equipment Technician (Senior)

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of the gas chromatographic analyzer (MSA Model 650). The following skill and knowledge requirements are representative of the category of tasks.

Skill Requirements

1. Ability to install and start-up the instrument including:

    a. Coordinating adjustment screw movement with delayed temperature readings given on a thermometer and voltmeter readings.

    b. Adjusting needle valves.

    c. Balancing T.C. Cell.

2. Ability to maintain the instrument including:

    a. Dismantling sliding plate valve.

    b. Replacing actuation cylinder seals (in sliding plate valve).

    c. Detecting damaged moving parts and mating surfaces (sliding plate valve).

    d. Lapping teflon gaskets and sliders and metal surfaces.

    e. Drilling out clogged ports in teflon slider.

    f. Cleaning sliding valve parts with methylene chloride, water, and acetone.

    g. Using torque wrench to evenly tighten sliding plate valve nuts.

    h. Checking cell block for leaks using helium at 30 to 60 psig. and helium leak detector.

    i. Replacing printed circuit card.

    j. Changing the total resistance value in the set point arm of the bridge circuit for temperature controller repair.

3. Ability to troubleshoot the instrument including:

    a. Identifying spiking on the recorder.

    b. Replacing detector elements with appropriate resistors from terminal strip of the programmer.

c. Detecting base line drift and wandering with manual attenuator at high gain position.

d. Back-flushing filters with clean air.

e. Checking sampling system for dirt or polymer buildup in sampling valve, inadequate back-flush of heavies, loss of power supply regulation, inadequate sample inject or charging time, or poor back pressure regulation.

f. Identifying cycling of peak height.

g. Monitoring AC power line frequency.

4. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.

5. Ability to read and interpret data from a table, psychometric chart, or a nomograph.

6. Ability to handle pressurized gas without endangering personnel or equipment.

7. Ability to coordinate adjustment screw or hand knob movements with meter or chart recorder reading to quickly achieve and maintain the desired reading.

8. Ability to read the recorder chart interpreting the position and slope of the tracing in terms of the variables represented on the ordinate and abscissa (i.e., the pollutant concentration over time or the strength of X-ray defraction as a function of beam angle).

9. Ability to level instrument or analyzer during installation using a level, plumb, screw adjusters, and/or shims.

10. Ability to service and operate a chart recorder, including replacing chart roll, resupplying ink (if required), and adjusting the baseline (zero) point, line density, chart speed, and sensitivity range.

11. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

12. Ability to detect leaks in hose, tubing, and piping connectors carrying liquids, gases, or vacuum using simple leak detection aids as appropriate.

13. Ability to disconnect and connect standard hose tubing and piping connectors without injury to threads and achieving leakproof connections. This includes the use of thread compound and teflon tape as appropriate.

14. Ability to disconnect and connect standard electrical connectors. This includes identifying leads to facilitate correct connection and achieving tight connections without damage to the leads of terminals.

15. Ability to correctly interpret function diagrams, wiring and tubing diagrams, simple electrical schematics, and troubleshooting charts.

16. Ability to interpret engineering drawings and piping diagrams.

17. Ability to use electrical test instruments such as:

    a. AC/DC voltmeter

    b. Ammeter

    c. Ohmmeter

    to achieve accurate circuit measurements without damage to the test instruments.

18. Ability to solder and unsolder electrical terminals making a good electrical and mechanical connection without shooting or grounding the connection or damaging circuit components.

19. Ability to detect pinched, ruptured or otherwise defective tubing and incorrect tubing connection.

20. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

Knowledge Requirements

1. Knowledge of procedure for installing the instrument including:

    a. How to protect instrument from excessive vibration, sun, and precipitation.

    b. How to run cabling using separate conduits.

    c. National Electrical Code, Class I, Group D, Division 1, requirements for making electrical connections in hazardous areas.

2. Knowledge of the procedure for starting up the instrument including:

    a. How to close and seal all electrical boxes before turning on power if analyzer is located in hazardous area.

    b. Start-up procedure.

    c. Air and carrier regulator adjustment specifications.

    d. Procedure for adjusting air and carrier regulators.

    e. All correct temperature set-point and flow rate specifications.

    f. Carrier flow modes.

3. Knowledge of the procedures for maintaining the instrument including:

    a. Sliding plate valve configuration.

    b. Procedure for determining the appropriate port size in teflon slider (sliding plate valve).

c. Proper handling techniques for acetone, methylene chloride, descalin, Freon type solvents.

d. Procedure for sliding plate valve disassembly and assembly.

e. "Run-in" technique required to obtain best operation from the newly assembled sliding plate valve.

f. Procedure for replacing Solenoid Pilot valve.

g. Procedure for replacing filaments in hot wire cell.

h. Procedure for removing detector block from analyzer.

i. Procedure for temperature controller repair.

j. Procedure for air heater replacement.

k. Procedure for maintaining micro-volume valves.

4. Knowledge of the procedure for troubleshooting the instrument including:

    a. Procedure for troubleshooting for electrical disturbances.

    b. Appropriate resistors with which to replace detector elements.

    c. Procedure for troubleshooting temperature disturbances (i.e., scalloping).

    d. Procedure for troubleshooting pressure and flow disturbances.

    e. Procedure for troubleshooting base line drift.

    f. Proper handling techniques for acetone and methylene chloride.

    g. Procedure for troubleshooting non-reproducibility.

    h. Procedure for troubleshooting inability to zero recorder.

i. Procedure for troubleshooting valving malfunctions.

j. Procedure for troubleshooting temperature control system.

5. Knowledge of the procedures for operating, maintaining, and troubleshooting Hydrogen Flame Ionization Detector (if used on the instrument).

6. Knowledge of the function and location of each operation and adjustment control on the instrument.

7. Knowledge of the name and location of the various component parts of the instrument.

8. Knowledge of the following procedures for the chart recorder used in conjunction with the instrument:

   a. Installation (including impedance matching)

   b. Servicing

   c. Troubleshooting

   d. Maintenance

   e. Calibration (including zeroing the recorder)

   f. Operation

9. Knowledge of the operating parameters for the instrument, including:

   a. Time for initiating sample collection

   b. Sampling duration

   c. Flow rate

10. Knowledge of the tools and materials required for maintaining the instrument.

References

1. Mine Safety Appliances Company. MSA process gas chromatographic analyzer, Model 650. Installation, operation, maintenance. Pittsburgh: Author.

Special Staffing Guidance

1. Because of the complexity of this task it should be assigned only to a senior level Equipment Technician.

2. The Equipment Technician assigned to operate and maintain this instrument should also operate and maintain the Gas Chromatograph Analyzer Programmer (see Page E-24) since these devices function as a unit.

Operation and Maintenance of a Colorimetric Air Monitoring System

Task Overview

A colorimetric air monitoring system (such as the Technicon) provides continuous automated wet-chemical analysis of ambient air for various parameters. The concentration level of the parameter being monitored is presented by a recorder on a moving strip of chart paper. The monitoring system is made up of four major parts: gas absorption system, proportioning pump, colorimeter, and recorder. The gas absorption system combines a continuous air sample with a liquid absorbing reagent at a precise rate, while the proportioning pump moves the fluids through the tubes in the monitoring system. The absorption level of a specific optical wavelength is determinedelectronically in the colorimeter whose electrical output causes variations in recorder pen movement (or provides a signal to a digital printer). The final readout gives the concentration level of the parameter being monitored. Briefly, the steps required for operation and maintenance of the colorimetric air monitoring system include:

1. Unpacking and installation of the instrument.
2. Preparation of the instrument prior to start-up.
3. Standardization of the liquid.
4. Start-up and shutdown (normal and emergency).
5. Routine maintenance of the components.
6. Troubleshooting the instrument.

Occupational Category: Equipment Technician

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of a colorimetric air monitoring system (the Technicon). The following skill and knowledge requirements are representative of that category of tasks.

Skill Requirements

1. Ability to prepare a colorimetric system for start-up and perform routine maintenance on it including:

   a. Determining if bubble patterns to colorimeter are evenly spaced.

   b. Using a stopwatch to determine the time required for a bubble to travel full length of flow rate pipette.

   c. Using appropriate solvent (e.g., Technicon Glidewire Solvent), general purpose oil, and Ribbon Dope Sealant.

   d. Correctly inserting reagent lines in distilled water to flush the system after shutdown.

   e. Cleaning proportioning pump rollers and platen with lint-free cloth and alcohol.

2. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

3. Ability to disconnect and connect standard electrical connectors. This includes identifying leads to facilitate correct connection and achieving tight connections without damage to the leads or terminals.

4. Ability to service and operate a chart recorder, including replacing chart roll, resupplying ink (if required), and adjusting the baseline (zero) point, line density, chart speed, and sensitivity range.

5. Ability to install measured amounts of reagents and distilled water in the analyzers without losing any and without contaminating them or the analyzer.

6. Ability to correctly interpret function diagrams, wiring and tubing diagrams, simple electrical schematics, and troubleshooting charts.

7. Ability to detect leaks in hose, tubing, and piping connectors carrying liquids, gases, or vacuum using simple leak detection aids as appropriate.

8. Ability to disconnect and connect standard hose tubing and piping connectors without injury to threads and achieving leakproof connections. This includes the use of thread compound and teflon tape as appropriate.

9. Ability to coordinate adjustment screw or hand knob movements with meter or chart recorder reading to quickly achieve and maintain the desired reading.

10. Ability to detect pinched, ruptured or otherwise defective tubing and incorrect tubing connection.

11. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.

12. Ability to read the recorder chart interpreting the position and slope of the tracing in terms of the variables represented on the ordinate and abscissa (i.e., the pollutant concentration over time or the strength of X-ray defraction as a function of a beam angle).

13. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

<u>Knowledge Requirements</u>

1. Knowledge of the procedures for installing appropriate reagents and reference solutions of the required concentrations and distilled water in the analyzer.

2. Knowledge of the function and location of each operation and adjustment control on the instrument.

3. Knowledge of the name and location of the various component parts of the instrument.

4. Knowledge of the following procedures for the chart recorder used in conjunction with the instrument:

   a. Installation (including impedance matching)

   b. Servicing

   c. Troubleshooting

   d. Maintenance

   e. Calibration (including zeroing the recorder)

   f. Operation

5. Knowledge of the operating parameters for the instrument, including:

   a. Time for initiating sample collection

   b. Sampling duration

   c. Flow rate

6. Knowledge of the tools and materials required for maintaining the instrument.

7. Knowledge of the procedure for installation and preparation of the instrument, including:

   a. Preliminary start-up procedure.

   b. Procedure for setting reagent baseline.

   c. Procedure for calibrating absorbing reagent flow rate.

   d. Procedure for liquid standardization.

8. Knowledge of the start-up and shutdown procedures for the instrument and the method for determining the time intervals desired for checking the reagent baseline.

9. Knowledge of the routine maintenance and troubleshooting procedures, including:

    a. Preventive maintenance schedule.

    b. Procedure for cleaning sample flow metering valve.

    c. Procedure for cleaning vacuum relief.

    d. Procedure for replacing defective fuse.

    e. Procedure for replacing air filter.

    f. Malfunction symptom patterns.

References

1. Technicon Instruments Corporation. Operation manual for the Technicon air monitor IV system, Part No. 181-A001-03. Technical Publication No. TA1-0264-00. Tarrytown, New York: Author, 1971.

Special Staffing Guidance

This task involves the handling of reagents and could be assigned in some combination with operation and maintenance of the following analyzers which also involve the use of reagents:

a. The Sequential Sampler.

b. The Coulometric Titration Analyzer.

Operation and Maintenance of the Sequential Sampler

Task Overview

The sequential sampler automatically gathers air samples for a given period of time and at given intervals. A diaphragm-type vacuum pump draws air through a set of impingers by way of a rotating precision plug valve. The samples gathered in the impingers can be removed from the device and transported to a laboratory for analysis. Briefly, the steps required for operation and maintenance of the sequential sampler include:

1. Installation of the instrument.
2. Continuous sampling operation.
3. Lapse sampling operation.
4. Changing impingers to collect samples.
5. Maintenance of the device.

Occupational Category: Equipment Technician

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of the sequential sampler (RAC Model PV). The following skill and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to install and operate the instrument, including:
   a. Setting timer to the correct clock time.
   b. Identifying which sample is functioning by squeezing shut hose and seeing if hose collapses toward the vacuum pump.
   c. Setting the correct timer trippers.
2. Ability to remove sample and service impingers in the instrument including properly cleaning impinger jets using a beaker of water.

3. Ability to maintain the instrument, including:

    a. Applying correct amount of oil to rear motor bearing without over oiling.

    b. Properly placing rubber shoulder washers to insure minimum pump vibration and noise.

    c. Cleaning caked material from plastic foam vapor barriers.

    d. Detecting leaks in vapor traps.

4. Ability to assemble sampling apparatus with each component in proper sequence using butt-to-butt connections, tygon tubing, and silicone or florocarbon grease as appropriate to create a leak-proof assembly.

5. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.

6. Ability to coordinate adjustment screw or hand knob movements with meter or chart recorder reading to quickly achieve and maintain the desired reading.

7. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

8. Ability to detect leaks in hose, tubing, and piping connectors carrying liquids, gases, or vacuum using simple leak detection aids as appropriate.

9. Ability to disconnect and connect standard hose tubing and piping connectors without injury to threads and achieving leakproof connections. This includes the use of thread compound and teflon tape as appropriate.

10. Ability to detect pinched, ruptured or otherwise defective tubing, and incorrect tubing connection.

11. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

Knowledge Requirements

1. Knowledge of the procedure for installing and operating instrument, including:
    a. Procedure for set-up of instrument for continuous sampling operation.
    b. Procedure for set-up of instrument for lapse sampling operation.
    c. Procedure for setting brass trippers on timer.
2. Knowledge of the procedure for removing and installing instrument and transporting it for analysis without sample loss or contamination.
3. Knowledge of the procedure for maintaining the instrument including:
    a. Knowledge of maintenance schedule.
    b. Procedure to obtain access to vacuum pump rear motor bearing oil cup.
    c. Procedure for removing pump from chassis.
    d. Procedure for dismantling pump to replace diaphragm and valve.
    e. Procedure for servicing vapor traps.
4. Knowledge of the function and location of each operation and adjustment control on the instrument.
5. Knowledge of the name and location of the various component parts of the instrument.

6. Knowledge of the operating parameters for the instrument, including:

    a. Time for initiating sample collection.

    b. Sampling duration.

    c. Flow rate.

7. Knowledge of the tools and materials required for maintaining the instrument.

References

1. Research Appliance Company. Operating and maintenance instructions, Model PV sequential sampler. Allison Park, Pennsylvania: Author, 1968.

Special Staffing Guidance

1. This task involves the handling of reagents and could be assigned in some combination with the following analyzer operation and maintenance tasks, also involving the use of reagents.

    a. Operation and Maintenance of a Colorimetric Air Monitoring System.

    b. Operation and Maintenance of the Coulometric Titration Analyzer.

2. It is assumed that the impingers used in the sequential sampler will be prepared (i.e., the reagents placed in the impingers) prior to sample collection and their contents analyzed in the laboratory.

3. This task is relatively uncomplicated and can be effectively performed by inexperienced personnel (provided with appropriate training).

Operation and Maintenance of the High Volume Air Sampler

Task Overview

The high volume sampler is designer for sampling large volumes of air for suspended particulate matter. This sampler consists of a specially housed vacuum sweeper motor to which a filter holder or adapter is attached. Air, drawn through the filter, is measured with a "visa-float" flowmeter calibrated in cubic feet per minute. Samples are usually collected for about 24 hours, with a flowmeter reading at the beginning and end of each sampling period. The average rate of flow is then determined from a calibration chart for each instrument. Briefly, the steps required for operation and maintenance of the high volume air sampler include:

1. Installation and normal operation of the device.
2. Calibration of the sampler.

Occupational Category: Equipment Technician

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of the high volume air sampler (RAC Model GMWL). The following skill and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to calibrate a high volume sampler visa-float flowmeter using a calibrating orifice assembly and manometer.
2. Ability to calibrate the calibrating orifice assembly water manometer using a positive displacement rotary-type meter.
3. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.
4. Ability to transport and handle filtering media using forceps if required so as not to contaminate it or lose material from it prior to weighing and analysis.

5. Ability to level instrument or analyzer during installation using a level, plumb, screw adjusters, and/or shims.

6. Ability to operate the High Volume Sampler including installing filter with an airtight seal around outer edge and removing it without loss of filter material or sample.

7. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

8. Ability to make accurate air flow measurement by maintaining the proper vertical orientation of the visa-float flowmeter.

Knowledge Requirements

1. Knowledge of the procedures for installing, servicing, troubleshooting, maintaining and operating the High Volume Sampler.

2. Knowledge of the procedure for calibrating the High Volume Sampler (including the proper correction factor to compensate for the reduction of pressure at the meter inlet caused by placing the calibration orifice before the inlet) and when the calibration procedure should be performed.

3. Knowledge of procedure for calibration of a calibrating orifice assembly and water manometer.

4. Knowledge of the procedure for installation, removal, and transportation of the High Volume Sampler filter.

5. Knowledge of the procedure for operation and care of the visa-float flowmeter to maintain its accuracy and prevent clogging.

6. Knowledge of the name and location of the various component parts of the instrument.

7. Knowledge of the operating parameters for the instrument including:

    a. Time for initiating sample collection

    b. Sampling duration

    c. Flow rate

8. Knowledge of the tools and materials required for maintaining the instrument.

References

1. Research Appliance Company. High volume air sampler, Model GMWL 2000, Model GMWL 2000H. Allison Park, Pennsylvania Author.

Special Staffing Guidance

The two-stage calibration process complicates what is otherwise a very simple instrument to operate and maintain. Since the high volume air sampler provides the samples used in various analyses, it is likely that many persons will need to know how to operate it (including filter installation, removal and transfer). Therefore, it may be advisable to assign calibration tc a more experienced Equipment Technician and the service and repair tasks can be performed effectively by a relatively inexperienced employee. Operation of the device can then be assigned to as many persons as required.

Operation and Maintenance of the A.I.S.I. Automatic Sampler

Task Overview

The A.I.S.I. Automatic Sampler records particulate or gas concentration over an extended period of time. The record obtained can be used to determine if concentrations are increasing or decreasing, and at what rate. Filter paper tape is fed through the sampling nozzle of the device where a known volume of air is drawn through the tape by an oil-less pump. The particulate matter contained in the air sample is deposited on the filter paper, while the clean exhaust air is used to produce a slight positive pressure in the sampler's front area to prevent contamination of the tape around sampling spots. Particulate concentration is determined by assessing the percent of light transmittance through the sample spot. This is done by comparing the light which reaches a photo cell after passing through a sample spot with the amount of light passing through clean filter paper. Briefly, the steps required for operation and maintenance of the A.I.S.I. Automatic Sampler include:

1. Preoperational check of the instrument.
2. Insertion of filter paper tape.
3. Setting the timer to obtain desired sample.
4. Adjusting flow rate to obtain desired sample.
5. Routine maintenance of the device.

Occupational Category: Equipment Technician

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of the A.I.S.I. Automatic Sampler (RAC Model G-2). The following skill and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to detect leaks in hose, tubing, and piping connectors carrying liquids, gases, or vacuum using simple leak detection aids as appropriate.

2. Ability to detect pinched, ruptured or otherwise defective tubing and incorrect tubing connection.

3. Ability to set the timer using the index knob to achieve desired sampling period through coordination with index switch indicator.

4. Ability to perform the routine maintenance procedure including washing the filter jars and filter felts and oiling the spool motor armature bearings.

5. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.

6. Ability to coordinate adjustment screw or hand knob movements with meter or chart recorder reading to quickly achieve and maintain the desired reading.

7. Ability to transport and handle filtering media using forceps if required so as not to contaminate it or lose material from it prior to weighing and analysis.

8. Ability to calibrate a sampling train or analyzer rotameter or flowmeter by making use of a wet test meter.

9. Ability to disconnect and connect standard hose tubing and piping connectors without injury to threads and achieving leakproof connections. This includes the use of thread compound and teflon tape as appropriate.

10. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

11. Ability to operate sampling apparatus or analyzer making quick and accurate adjustments in flow control devices in order to maintain a predetermined sample flow rate and terminating the sampling process precisely at a predetermined time.

12. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

Knowledge Requirements

1. Knowledge of the following procedures for the A.I.S.I. sampler:
    a. Preoperational checkout.
    b. Filter paper tape insertion.
    c. Setting timer.
    d. Adjusting flow rate.
    e. Routine maintenance.
2. Knowledge of the procedure for determining relative humidity.
3. Knowledge of the function and location of each operating and adjustment control on the instrument.
4. Knowledge of the name and location of the various component parts of the instrument.
5. Knowledge of the operating parameters for the instrument, including:
    a. Time for initiating sample collection
    b. Sampling duration
    c. Flow rate
6. Knowledge of the tools and materials required for maintaining the instrument.

References

1. Research Appliance Company. Operating instructions for G-1. G1-H_2S, G-2, G2-H_2S, A.I.S.I. Samplers. Allison Park, Pennsylvania: Author.

Special Staffing Guidance

The A.I.S.I. Automatic Sampler is a relatively straightforward device to operate and maintain and could be effectively assigned to a new or inexperienced employee (provided with the appropriate training).

Operation and Maintenance of the Wind Speed Transmitter

Task Overview

The wind speed transmitter consists of three major sections: anemometer cup assembly, transmitter housing assembly, and, depending on model, a magnet-reed switch or a light chopper-amplifier assembly. The anemometer cup assembly consists of three arms with conical cups attached to, or molded directly on, the arm. This assembly drives a shaft which enters the transmitter housing assembly and is securely sealed against extreme environmental conditions. If the magnet-reed switch transmitter is used, the anemometer cup assembly is mechanically linked to a miniature magnet by the driveshaft. Rotation of the magnet alternately opens and closes the contacts of the reed switch, producing two contact closures with each revolution of the cups. The second type of transmitter used, the light beam chopper-amplifier, has the driveshaft connected to the beam chopper. A small lamp is mounted directly above the slot chopper disc so that its light passes through the slots onto the photo-diode mounted beneath the disc. Rotation of the chopper alternately masks and exposes the diode to the lamp, producing electrical pulses at a frequency proportional to the rate of rotation of the cups. The diode output is applied to the amplifier circuit contained within the transmitter, amplifying the pulses to a uniform 10 volt peak-to-peak value. Briefly, the steps required for operation and maintenance of the wind speed transmitter include:

1. Unpacking and installation of the transmitter.
2. Routine maintenance.
3. Periodic check of the transmitter.
4. Replacement of the transmitter bearing.
5. Replacement of the reed switch transmitter (magnetic-reed switch type).
6. Replacement of the transmitter lamp (light-chopper-amplifier type).
7. Troubleshooting of the device.

Occupational Category: Equipment Technician

Task Description

References 1 and 2 provide examples of the procedures for operation and maintenance of the wind speed transmitter (Climet Models 011-2B and 011-1). The following skills and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to unpack and install the instrument including:
    a. Mounting anemometer cup assembly onto transmitter shaft without marring shaft through excessive tightening of set screw.
    b. Determining that shaft bearings are not damaged through hand rotation of the cup assembly.
2. Ability to perform routine maintenance and periodic checks on the instrument including:
    a. Replacing transmitter bearings.
    b. Removing anemometer cup assembly from rotating hub without damage to the equipment.
    c. Detecting crack and breaks in cups.
    d. Pulling base away from top housing assembly without damaging either part.
    e. Detecting loose magnet or corrosion in interior of the transmitter, especially soldered contacts of reed switch (e.g., in Model 011-1).
    f. Detecting dust particles and fungus on light chopper without bending chopper (e.g., in Model 011-1).
    g. Detecting cracks and corrosion on amplifier circuit board and repair cracks in protective finish with sealant such as Humi Seal 1A27 (e.g., in Model 011-1).

h. Determining out-of-tolerance roughness in shaft rotation, or excessive end play.

i. Properly greasing transmitter "O" rings.

3. Ability to repair and troubleshoot the instrument including:

a. Removing anemometer cup assembly from rotating hub without damage to the equipment.

b. Removing shaft from top housing assembly without losing spacers.

c. Removing shield and slinger without bending chopper disc (e.g., in Model 011-1).

d. Installing bearings without introducing dirt particles.

e. Disassembling and assembling transmitter.

f. Positioning new reed switch so that top of envelope is the proper distance from the bottom of rotating magnet. (e.g., in Model 011-1).

g. Operating a DC voltage supply (e.g., in Model 011-1).

h. Operating an oscilloscope (e.g., in Model 011-1).

i. Moving lamp in socket until wave shape displayed on oscilloscope matches given standard (e.g., in Model 011-1).

j. Securing lamp and light assembly and protecting it with sealant such as Humi Seal 1A27 (e.g., in Model 011-1).

k. Detecting faulty circuit boards (e.g., in Model 011-1).

l. Detecting faulty photo-diode (e.g., in Model 011-1).

m. Detecting faulty reed switch (e.g., in Model 011-2B).

4. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

5. Ability to disconnect and connect standard electrical connectors. This includes identifying leads to facilitate correct connection and achieving tight connections without damage to the leads or terminals.

6. Ability to correctly interpret function diagrams, wiring and tubing diagrams, simple electrical schematics and troubleshooting charts.

7. Ability to use electrical test instruments such as:

    a. AC/DC voltmeter

    b. Ammeter

    c. Ohmmeter

    to achieve accurate circuit measurements without damage to the test instruments.

8. Ability to solder and unsolder electrical terminals making a good electrical and mechanical connection without shorting or grounding the connection or damaging circuit components.

9. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

<u>Knowledge Requirements</u>

1. Knowledge of the procedure for unpacking and installing the instrument including:

    a. Procedure for preparing wind speed transmitter for operation.

    b. Knowledge of the type of environment in which transmitter is to be used. Vent hold at bottom of housing must be plugged if used in dry, dusty conditions.

2. Knowledge of the procedures for performing routine maintenance and periodic checks on the instrument.

3. Knowledge of the procedures for repairing and troubleshooting the instrument including:

   a. The procedure for bearing replacement.

   b. The procedure for switch replacement (e.g., in Model 011-2B).

   c. The procedure for lamp replacement (e.g., in Model 011-1).

   d. Knowledge of malfunction symptom patterns.

4. Knowledge of the function and location of each operating and adjustment control on the instrument.

5. Knowledge of the name and location of the various component parts of the instrument.

6. Knowledge of the tools and materials required for maintaining the instrument.

References

1. Climet Instruments Company. Instruction manual, Model 011-2B, wind speed transmitter. Sunnyvale, California: Author, April 1970.

2. Climet Instruments Company. Instruction manual, Model 011-1, wind speed transmitter. Sunnyvale, California: Author, April 1970.

Special Staffing Guidance

1. Because of the relative simplicity of this task it can be effectively performed by a relatively inexperienced Equipment Technician (with the appropriate training).

2. This task and the operation and maintenance of the wind direction transmitter should be performed by the same person since they normally will be installed and operated together and their functions are related.

3. The operation and maintenance of this instrument may also fall within the responsibility of the meteorology section of the agency.

Operation and Maintenance of the Wind Direction Transmitter

Task Overview

The wind direction transmitter consists of four parts: the wind vane, a potentiometer drive, a logic circuit, and the housing. The wind vane is a light-weight airfoil attached or molded to one end of a rod. A counterweight is attached to the other end of the rod and the vane hub is located at the vane's center of gravity. The hub is attached to the potentiometer drive which consists of a drive shaft mounted on precision ball bearings, and is attached to a pair of potentiometers (the transmitter analyzed has a 540° horizontal wind direction system). In the 540° system described here, two identical potentiometers are mounted on the same shaft. A pulse, generated when the wiper passes the gap of one potentiometer, drives a flip-flop contained within the logic circuit which switches to the output of the other potentiometer. A constant voltage is supplied to the potentiometers; the output voltage from the potentiometers is dependent upon the azimuth position of the vane. The logic circuit contains the flip-flop and a regulated power supply which provides the potentiometers with operating voltage. The potentiometer drive coupler, potentiometers, and the logic circuit are contained in a weatherproofed housing. The housing also mounts the electrical receptacle which mates with the connecting cable. Briefly, the steps required for operation and maintenance of the wind direction transmitter include:

1. Unpacking and installation of the transmitter.
2. Routine maintenance.
3. Periodic check of the transmitter.
4. Replacement of the transmitter bearing.
5. Calibration of the transmitter.
6. Replacement of the electronic module.

7. Replacement of the potentiometer.

8. Troubleshooting of the device.

Occupational Category: Equipment Technician

Task Description

References 1 and 2 provide examples of the procedures for operation and maintenance of the wind direction transmitter (Climet Models 012-6C and 012-10). The following skill and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to unpack and install the instrument including:

    a. Balancing the vane assembly in the vane mount.

    b. Mounting vane assembly without marring shaft through excessive tightening of set screw.

    c. Aligning wind direction transmitter using special compass designed to align bushing prior to inserting transmitter.

    d. Determining that shaft bearings are not damaged through hand rotation of the vane assembly.

2. Ability to perform routine maintenance and periodic checks on the instrument including:

    a. Properly greasing transmitter "O" rings.

    b. Replacing transmitter bearings.

    c. Removing vane assembly without disturbing the orientation of the vane (do not loosen lower set screw in vane mount).

    d. Pulling base away from top housing assembly without damaging either part.

    e. Detecting loose connection between drive shaft and potentiometers.

f. Detecting loose solder connections on potentiometers.

g. Detecting cracks and corrosion on amplifier circuit board, and repair cracks in protection finish with sealant such as Humi Seal 1A27.

h. Determining out-of-tolerance roughness in shaft rotation, or excessive end play.

3. Ability to repair and troubleshoot the instrument including:

   a. Removing anemometer cup assembly from rotating hub without damage to the equipment.

   b. Removing shaft from top housing assembly without losing spacers.

   c. Removing shield and slinger without damage to the instrument.

   d. Installing bearings without introducing dirt particles.

   e. Checking power supply in recording equipment.

   f. Detecting faulty logic module.

   g. Detecting failure to change from "A" channel to "B" channel.

   h. Differentiating between faulty bearings and frozen potentiometer shaft.

4. Ability to calibrate the instrument including:

   a. Removing and replacing transmitter on mast.

   b. Removing and replacing cover and vane assembly.

   c. Operating a variable voltage supply and connecting it to the transmitter.

   d. Connecting calibrator to transmitter.

   e. Aligning reference marks on top of housing.

f. Rotating transmitter hub until lowest reading is obtained on voltmeter.

g. Loosening set screws and rotating calibrator pointer to 0^{o} while holding pot stationary.

h. Coordinating voltage adjustments on circuit board with voltage reading on voltmeter.

5. Ability to detect instrument damage caused by shipping, including dents, breakage, components knocked out of position, loose electrical and mechanical connections, and hairline cracks in glass parts.

6. Ability to disconnect and connect standard electrical connectors. This includes identifying leads to facilitate correct connection and achieving tight connections without damage to the leads or terminals.

7. Ability to correctly interpret function diagrams, wiring and tubing diagrams, simple electrical schematics, and trouble-shooting charts.

8. Ability to use electrical test instruments such as:

   a. AC/DC voltmeter

   b. Ammeter

   c. Ohmmeter

   to achieve accurate circuit measurements without damage to the test instruments.

9. Ability to solder and unsolder electrical terminals making a good electrical and mechanical connection without shorting or grounding the connection or damaging circuit components.

10. Ability to detect a worn, corroded, dirty, broken or otherwise defective component part by visual, tactile, or auditory examination and comparison with a properly functioning part.

Knowledge Requirements

1. Knowledge of the procedure for unpacking and installing the instrument including:

   a. Procedure for preparing wind direction transmitter for operation.

   b. Knowledge of use of special Compass Orientation Device.

   c. Knowledge of the type of environment in which transmitter is to be used and the extra protective procedures necessary in extreme environments.

2. Knowledge of the procedure for performing routine maintenance and periodic checks on the instrument.

3. Knowledge of the procedures for repair and troubleshooting of the instrument including:

   a. Procedure for bearing replacement.

   b. Procedure for replacing electronic module.

   c. Procedure for potentiometer replacement.

   d. Knowledge of malfunction symptom patterns.

4. Knowledge of the procedure for calibrating the instrument including:

   a. Procedure for calibration of the transmitter.

   b. Procedure for use of a calibrator (as required).

   c. Procedure for orienting the transmitter (as required).

5. Knowledge of the function and location of each operating and adjustment control on the instrument.

6. Knowledge of the name and location of the various component parts of the instrument.

7. Knowledge of the tools and materials required for maintaining the instrument.

References

1. Climet Instruments Company. Instruction manual for Climet instructions, Model 012-6C, wind direction transmitter. Sunnyvale, California: Author, April 1970.

2. Climet Instruments Company. Instruction manual, Model 012-10, wind direction transmitter. Sunnyvale, California: Author, March 1971.

Special Staffing Guidance

1. Because of the relative simplicity of this task it can be effectively performed by a relatively inexperienced Equipment Technician (with the appropriate training).

2. This task and the operation and maintenance of the wind speed transmitter should be performed by the same person since they normally will be installed and operated together and their functions are related.

3. The operation and maintenance of this instrument may also fall within the responsibility of the meteorology section of the agency.

Supervision of Air Monitoring Equipment Operation and Maintenance Tasks

Task Overview

This task involves the supervision of operation and maintenance of the analyzers and samplers used to monitor pollutant levels in air samples. The task also involves scheduling and coordinating the use of the equipment in routine and special operation (e.g., in conjunction with the smog chamber).

Occupational Category: Chemist

Task Description

The procedure for supervising air monitoring equipment operation and maintenance cannot be set down in a step-by-step sequence but involves various steps which are performed as often as the supervisor deems necessary in achieving timely and high quality results. These steps include:

1. Initiate the performance of the operation and maintenance activities or assure that the activities are performed as scheduled. This includes making work assignments.
2. Supervise the conduct of the activities, providing assistance as required.
3. Advise of special problems or contingencies which might affect when and how the activities are performed in a given instance (e.g., the need for non-scheduled sampling or the temporary presence of an interferent the effect of which must be overcome or allowed for by special procedures).
4. Review the written report of the analyses for inconsistencies, mistakes, variations from the procedure, etc.
5. Assure that records of all analysis are in proper form, complete, and correctly filed.

6. Provide on-the-job training for all tasks in support of or in lieu of formal training provided elsewhere.

7. Assist professional staff personnel from other parts of the agency in planning and scheduling non-routine analysis (e.g., special remote site testing or smog chamber research).

Skill Requirements

1. Ability to evaluate the quantity and quality of work produced by the staff and discriminate acceptable from unacceptable performance. This skill assumes the ability to use criteria of performance acceptability for all tasks supervised.

2. Ability to make work assignments and establish and maintain work schedules such that deadlines are met consistently.

3. Ability to develop work procedures which provide detailed step-by-step guidance in the performance of the equipment operation and maintenance tasks

4. Ability to document all procedures, findings, ideas, and decisions in writing which communicates clearly and completely to the intended audience (e.g., the Equipment Technicians).

5. Ability to effectively communicate verbally with Equipment Technicians concerning details of task performance.

6. Ability to cooperate with other agency personnel in planning tests so as to assure proper coordination of routine and special sample collection and analysis activities.

7. Ability to express technical theory and data in a concise, intelligent manner.

8. Ability to choose a sampling time length and flow rate in accordance with requirements for sample reliability and representativeness and to avoid overloading the capacity of the various reagents, filters, traps, etc., in the equipment.

9. Ability to determine the extent to which equipment and instrument installation, troubleshooting, maintenance, and calibration should be performed by agency personnel given:

    a. The frequency with which these functions must be performed.

    b. The availability of the required skills and knowledge in-house or the cost of providing them through training or selection.

    c. The availability of the required test instruments, tools, and materials or the cost of providing them.

    d. The cost and delay associated with having some part of these functions performed outside the agency.

<u>Knowledge Requirements</u>

1. Knowledge of the capabilities and work loads of the personnel under his direction sufficient to permit the making of work assignments.

2. Knowledge of the theoretical principles of operation for the equipment of concern.

3. Knowledge of the factory recommended installation, service, troubleshooting, repair, and calibration procedures for all laboratory equipment of concern.

4. Knowledge of the limitations associated with the analyzers being employed including:

    a. Range of ambient concentration of the pollutant for which the analyzer can be employed and means of modifying its sensitivity.

    b. Other constituents which interfere with the accuracy of the analyzer and methods for controlling their effect.

   c. Critical aspects of analyzer operation (e.g., the need for stable operating voltage or precise operating temperature) and means of assuring that these aspects are adequately provided for.

5. Knowledge of the effects of typical reagent impurities on the outcome of the analysis of concern.

6. Knowledge of factors surrounding the choice of appropriate analysis technique, e.g., the use of automated (i.e., analyzers) versus standard manually performed analyses.

7. Knowledge of each source which is pertinent to identifying new analytical methodology, its use and location.

8. Knowledge of the meaning of the following terms which are used in the evaluation of a method:

   a. Validity

   b. Reliability

   c. Accuracy

   d. Precision

9. Knowledge of hazards involved with performing specific types of analytical tasks, such as:

   a. Presence of volatile or explosive chemicals

   b. Poisonous substances

   c. High temperatures or pressures

10. Knowledge of relevant factors sufficient to permit the development and periodic revision of a sampling schedule giving the times, durations, and locations of sampling for each ambient air sampling and analysis procedure to be employed. Relevant factors affecting the schedule include:

   a. Agency policy.

   b. Current pollution levels.

c. Expected pollution levels.

d. Changes in the set of pollutants for which analyses are routinely performed.

e. Changes in sampling or analysis procedures.

f. Initiation of experimental monitoring programs.

11. Knowledge of the relevant factors sufficient to permit the establishment and periodic revision of the sample flow rate to be maintained in the various sampling procedures. Relevant factors affecting flow rate include:

a. Instrument manufacturers' recommendations

b. Expected pollutant concentrations

c. Efficiency of the sample and analyses processes

12. Knowledge of the operation of each analyzer sufficient to:

a. Identify errors possible in each step of the analysis process and their effect on the final outcome of the analysis.

b. Identify critical steps in the process. A critical step is one in which:

1) Out-of-tolerance operation of the analyzer is known to frequently occur.

2) Little margin for out-of-tolerance operation exists.

3) Out-of-tolerance operation is likely to go undetected.

c. Revise procedures so as to reduce the likelihood of out-of-tolerance operation.

13. Knowledge of the chemical, electrical, and mechanical principles of operation of the various analysis instruments sufficient to:

    a. Identify instrument malfunctions which could go undetected and result in inaccurate read-out (to the extent not already documented in existing service manuals).

    b. Develop procedures for the timely discovery of such malfunctions.

    c. Identify the effects of incorrect instrument operation on instrument read-out.

<u>Special Staffing Guidance</u>

Because of the skill and knowledge requirements, level of responsibility, and credibility characteristics of this task, it is suggested that it be assigned to a Chemist. The assignee should be able to perform all the operation and maintenance tasks performed by the Equipment Technicians under his supervision. But he needs, in addition, familiarity with general laboratory equipment maintenance, general theoretical background relevant to the analyses to be performed, and the specific principles of operation of the laboratory instruments used for the analyses.

It is suggested that the supervisor of monitoring equipment operation and maintenance also supervise the tasks covered in the Laboratory Support function (see Volume D, pages D-4 through D-55). Both involve the performance of analytical chemistry procedures to determine pollutant concentrations in air samples, the former by manual analyses and the latter by automated techniques.

Use of the Smog Chamber as a Tool in Photochemical Smog Research[1]

Task Overview

The smog chamber is used to facilitate research into factors contributing to the production of smog, effects of smog on organic and inorganic materials, and techniques for controlling smog. The smog chamber consists of four major component groups, the chamber box, air supply system, light source, and monitoring equipment. The chamber is a sealed box; the larger the box, the more valid are the results from the smog research. Clean, uncontaminated air is supplied to the chamber through an air purification system consisting of a series of filters of various kinds, a heater, and a humidifying unit. The chamber operator controls the pressure within the chamber with inlet and outlet valves, the temperature of incoming air is controlled, as is the relative humidity within the chamber. Contaminants are introduced to the chamber through the air system, either in the gaseous state or as liquids. The chamber operator has control over the volume of the contaminants added and thereby the concentration within the chamber. The light source is commonly a series of lights and filters which provide light in the UV range of 2900 A and above. The number of lights and distance of the light panel from the chamber is under the control of the operator. Finally, the concentration of reaction products within the chamber is monitored by various instruments. The parameters which are often monitored include CO or Freon, hydrocarbon, NO, NO_2, total oxidant, ozone, SO_2, aerosols, aldehydes, and PAN. In addition, subjective observations are often made of eye irritation. Briefly, the steps commonly required for use of the smog chamber in research include:

1. Pre-experiment preparation.
2. Conduct of the experiment.
3. Subjective measurement of eye irritation.

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[1] This task will be performed only in those agencies with access to a smog chamber or similar experimental facility.

NOTE: It is assumed that the experimental design and a step-by-step experimental scenario has been created by a trained scientist (i.e., a chemist). This scenario describes:

a. Task steps for the specific experiment.

b. Time for each step to be performed.

c. Volume and concentration of each contaminant which must be added to the chamber.

d. Measurement techniques to be employed.

This analysis is restricted to the implementation of the smog chamber as a tool in air quality research.

Occupational Category: Equipment Technician (Senior)

Task Description

Pre-experiment Preparation:

1. Read experimental scenario carefully. Be certain to understand all terminology and procedures.

2. Identify all parameters which must be duplicated in the smog chamber as given in the experimental design and assemble necessary contaminants.

3. Identify and list each subjective measurement technique to be used in the experiment, such as eye irritation, visibility reduction, etc.

    a. Identify type of sensory capabilities required by the observers, e.g., visual acuity, olfactory, etc.

    b. Identify the number of observers required.

    c. Obtain the required subject.

4. Identify each mechanical or chemical measurement technique to be used in the experiment, such as required to measure aerosol formation, NO_2 formation, aldehyde formation, etc.

a. Identify measurement instrument to be used by make and model.

b. Review operational procedures for the measurement devices.

c. Assemble and prepare instrumentation.

Conduct of the Experiment:

1. Start up all instrumentation and assure that each has reached a stable operating condition.

2. Adjust pressure control to achieve desired chamber pressure.

3. Adjust temperature control to achieve desired temperature.

4. Set desired relative humidity using the control panel. Be sure to take into account the steady-state temperature inside the chamber and set the humidity control to correspond with the temperature.

5. Check relative humidity by reading hydrometer located inside the smog chamber.

Skill Requirements

1. Ability to perform pre-experiment preparation for use of the smog chamber including:

   a. Identifying in the scenario each parameter to be duplicated in smog chamber and the methods to be used in duplicating them.

   b. Identifying subject measurement procedures to be used.

   c. Describing necessary sensory characteristics of the observers.

   d. Identifying and describing mechanical and chemical measurement procedures to be used.

   e. Setting up the required monitoring equipment.

2. Ability to conduct an experiment using the smog chamber including:

   a. Adjusting controls to achieve desired pressure, temperature, and humidity.

   b. Determining necessary moisture requirements given steady-state temperature within chamber.

   c. Reading hydrometer and interpreting reading in terms of relative humidity.

   d. Adjusting gas flow using regulator control to achieve desired concentrations of gaseous contaminants in chamber.

   e. Adding liquid contaminants through system using syringe.

   f. Operating and reading measuring equipment being used in the experiment.

   g. Adjusting light bank concentration, wave lengths, and distance from chamber.

3. Ability to achieve accurate measurement of eye irritation in the smog chamber through instruction to subjects regarding how to detect earliest indication of eye irritation.

4. Ability to accurately obtain definite volumes of solutions using apparatus such as a pipette, syringe, volumetric flask, or burette.

5. Ability to operate sampling apparatus or analyzer, making quick and accurate adjustments in flow control devices in order to maintain a predetermined sample flow rate and terminating the sampling process precisely at a predetermined time.

6. Ability to read indicating devices, such as a thermometer, manometer, dry gas meter, and flowmeter, and to interpret meter readings against a calibration plot as required.

7. Ability to handle pressurized gas without endangering personnel or equipment.

8. Ability to coordinate adjustment screw or hand knob movements with meter or chart recorder reading to quickly achieve and maintain the desired reading.

9. Ability to read the recorder chart interpreting the position and slope of the tracing in terms of the variables represented on the ordinate and abscissa (i.e., the pollutant concentration over time or the strength of X-ray defraction as a function of beam angle).

10. Ability to service and operate a chart recorder, including replacing chart roll, resupplying ink (if required), and adjusting the baseline (zero) point, line density, chart speed, and sensitivity range.

11. Ability to detect leaks in hose, tubing, and piping connectors carrying liquids, gases, or vacuum using simple leak detection aids as appropriate.

12. Ability to disconnect and connect standard hose tubing and piping.connectors without injury to threads and achieving leakproof connections. This includes the use of thread compound and teflon tape as appropriate.

13. Ability to disconnect and connect standard electrical connectors. This includes identifying leads to facilitate correct connection and achieving tight connections without damage to the leads or terminals.

14. Ability to correctly interpret function diagrams, wiring and tubing diagrams, simple electrical schematics, and troubleshooting charts.

15. Ability to detect pinched, ruptured or otherwise defective tubing and incorrect tubing connection.

Knowledge Requirements

1. Knowledge of the procedures for pre-experiment preparation of the smog chamber including:

    a. Knowledge of experimental scenario for research to be conducted in smog chamber.

    b. Meaning of scientific terminology used in the scenario.

    c. Procedure to be followed during experiment as described in scenario.

    d. Procedure for duplicating atmospheric parameters identified for the experiment.

    e. Procedure for obtaining the given subjective measure.

    f. Procedures for mechanical and chemical measurement.

    g. Availibility of required measurement and monitoring equipment and the procedures for obtaining it.

    h. Necessary time relationships between various steps of the experiment.

    i. Procedure for obtaining the required contaminants.

2. Knowledge of procedures for conducting an experiment in the smog chamber including:

    a. Desired chamber pressure, temperature, and humidity.

    b. Procedure for introducing air and contaminants into chamber.

    c. Desired contaminant concentrations.

    d. Knowledge that reactive hydrocarbon should be added last.

    e. Proper light combination as prescribed in experimental scenario.

f. Procedures for operating monitoring equipment.

g. Instrument monitoring schedule.

3. Knowledge of the procedure for obtaining eye irritation measurements using the smog chamber.
4. Knowledge of the procedure for determining relative humidity.
5. Knowledge of the function and location of each operating and adjustment control on the smog chamber.
6. Knowledge of the name and location of the various component parts of the smog chamber.
7. Knowledge of the following procedures for the chart recorder used in conjunction with the smog chamber:

   a. Installation (including impedance matching)

   b. Servicing

   c. Troubleshooting

   d. Maintenance

   e. Calibration (including zeroing the recorder)

   f. Operation

8. Knowledge of the tools and materials required for maintaining the smog chamber.
9. Knowledge of the procedure for maintaining the smog chamber.

References

1. Levy, A., Miller, S., & Himes, R. The smog chamber - a tool for the study and control of photochemcial smog. Columbus, Ohio: Battelle Memorial Institute, Columbus Laboratories, 1967.

Special Staffing Guidance

This task requires, in addition to the ability to operate and maintain the smog chamber, the ability to correctly set up and operate associated instrumentation. It also requires administrative abilities in the sense that the assignee must coordinate procurement of required equipment, materials, and subjects with the actual conduct of the experimental procedure. Further, to effectively aid the scientist in the conduct of experiments using the smog chamber the Equipment Technician should be able to understand something of the theory behind the step-by-step procedure he is performing. For these reasons, the Equipment Technician assigned to this task should:

1. Be highly experienced in the instrumentation available for use with the smog chamber.
2. Be familiar with the policies of the agency concerning procurement of equipment, materials and subjects.
3. Have background sufficient to work with abstract theoretical principles as provided by the scientific staff.

For the above reasons it is suggested that the assignee be a senior level Equipment Technician.

Design of an Air Monitoring Facility

Task Overview

The design of an air monitoring facility (AMF) involves three major activities including, the establishment of design goals, the selection of instrumentation and other equipment which will allow the goals to be met, and the design of the physical layout of the facility (References 1 and 2). The first activity category is the establishment of design goals. The goals must be clearly stated in such a manner as to allow the designer to know when he has achieved the goal. In setting design goals, the first question which must be answered concerns the purpose for which the facility is being created, i.e., will its main function be to collect data for pollution control, or will its main function be the collection of data for research? Once the primary reason for existence has been identified, the next question is where to locate the facility. If control is the major concern, the designer may choose to locate the facility near the source of pollution, or he may choose to locate near the area to be protected. This decision is of course, based upon the purpose for the creation of the AMF. There are times when the optimum location for the AMF is in a rural setting to allow research into the effects of pollution on the rural environment, e.g., plant ecology, etc. Regardless of where the facility is located, it will be necessary to specify the type of pollutants which will be monitored as well as their likely concentrations. The type of pollutants will affect decisions concerning the kind of equipment necessary, while the expected concentrations will dictate equipment sensitivity or threshold requirements.

A number of external constraints must be considered aside from the purpose of the facility, location, and type of pollutants monitored. Some of these constraints include the natural environment, e.g., the presence of unusual air currents, temperature problems, etc.; economic factors, e.g., how large is the budget; legal implications, which are particularly relevant if the data from the facility is to be used to enforce pollution laws; and social, political, and manpower factors.

Finally, the designer must identify the degree of flexibility required for the AMF. A number of alternatives are available including a fixed location facility, a mobile van installation, or multiple telemetered sites. The degree of flexibility required is based upon the purpose for the facility. If control is the primary reason for establishment of the AMF, a fixed location may be all that is needed. For research however, data from more than one location is usually required and therefore the designer will have to consider either multiple sites or a mobile van.

Once the designer has specified the goals for the AMF, he must choose the equipment to be included in the facility, and equipment selection is contingent upon the analytical techniques chosen for inclusion in the AMF.

After identifying the general analysis techniques and types of equipment needed, the designer must specify make and model for procurement. Often the designer will have formal evaluation reports at his disposal. If this is the case he can study the reports to identify the least expensive equipment which will fulfill his requirements for accuracy, specificity (limited interference with the measurement of a given pollutant by other substances), and reliability. If the evaluation data is not available, the designer may have to judge between several similar devices concerning their applicability for his particular installation.

Facility layout should adhere to good architectural and engineering practices. In addition, a number of special considerations must be made should a mobile van installation be planned.

Briefly, the steps required for designing an air monitoring facility include:

1. Establishment of design goals.
2. Selection of instruments and analytical methods to be included in the facility.
3. Layout of the air monitoring facility.
4. Design of a mobile van used for air monitoring.

Occupational Category: Chemist (Senior)

Task Description

Establishment of design goals:

1. Determine the degree to which the data from the AMF will be used for pollution control purposes.
2. Determine the degree to which the data from the AMF will be used for research purposes.
3. Specify all other data usages.
4. Identify format in which data must be presented to facilitate each of the users.
5. Specify the location for the facility based on the purposes for its creation.
6. Identify the type of pollutants likely to be found in the area in which the AMF is to be located.
7. Specify the likely concentrations of pollutants which will be found in the area in which the AMF is to be located.
8. Determine the minimum concentration levels which must be detected.
9. Identify unusual environmental problems which may be present in the proposed location, e.g., unusual air currents, temperatures, etc.
10. Determine the budget range available for the proposed AMF.
11. Check legal restrictions in the area in which the facility is to be located. These restrictions include zoning laws, construction codes, pollution laws, etc.
12. Assess social and political environment to determine if unforeseen problems will arise over the placement of an AMF in the locale selected.
13. Assess manpower availability required to staff the AMF.

14. Specify if fixed, mobile, or multiple site monitoring is needed.

15. Document all findings and decisions.

Selection of instruments and analytical methods to be included in the facility:

1. List each of the measurements which are to be made.

2. List all measurement techniques available for each measurement which is desired.

    NOTE: Particulate monitoring is accomplished by some form of air filtering process. Commonly used techniques include use of high volume air samplers (see Page E-46) and use of tape samplers (see Page E-49). Sulfur dioxide is measured by secondary coulometry and dynamic iodimetric titration (see Page E-15), the West-Gaeke method (see Page D-9), or flame photometry. The NO, NO_2, and oxidant analyzers also use the coulometric principle based on the oxidation of potassium iodide (see Page E-15). Oxidants are measured with a number of different devices and the oxides of nitrogen can be measured through the use of wet chemical Saltzman method (see Page D-4). Carbon monoxide is usually measured with a non-dispersive infrared instrument (see Page E-10). Hydrocarbons are measured by the flame ionization technique (see Page E-4). A single instrument which has a wide range of applications in the analysis of gases is the gas chromatograph analyzer which carries out vapor phase chromatographic analysis of a variety of samples (see Page E-29). An essential part of any AMF is several types of meteorological instruments, including wet- and dry-bulb temperature indicator, barometer, rain and snow gauges, wind speed and wind direction indicators (see Pages E-53 and E-58).

3. List all hardware which is readily available on the market for each of the measurement techniques listed in step 2, and which meets sensitivity requirements.

4. List all support materials needed for each of the commercially available measurement devices and techniques, e.g., hydrogen, 220 VAC, reagents, etc.

5. Gather information about each candidate instrument in each of the following categories:

   a. Sensitivity of the instrument including the validity and reliability of obtained measurements.

   b. The response time required to note change in environmental conditions after the change has occurred.

   c. The readability of the meters or recorders associated with the instrument.

   d. The compactness and portability of the instrument.

   e. The ease of operation and maintenance, e.g., if rack-mounted, it should use drawers, rollers, or hinges, such that complete access will be available to all components.

6. Rank equipment within each category of measurement in terms of its overall acceptability to meet the measurement requirements based on the parameters identified in step 5.

7. List cost of each measuring device with the device description as ranked in step 6.

8. Reexamine ranking to assure that the benefits of the most desirable equipment are compatible with the cost of the equipment (i.e., examine value received for dollar spent).

9. Make up procurement list of the equipment items to be purchased.

10. Indicate in the procurement request that the manufacturer will supply or comply with requirements including the following:

    a. Detailed principles of operation and analysis.

    b. Possible interferences.

    c. Instrument characteristics including accuracy, sensitivity, linearity, resolution, drift, response time, lag time, output signal, output impedance, and output noise.

    d. Power requirements.

    e. Temperature and pressure range within which the instrument can be operated.

    f. Spare parts necessary for one-year normal operation.

    g. A one-year guarantee and specified turn-around time.

    h. At least five copies of instruction maintenance and repair manuals.

    i. Electronic circuit diagrams (solid state preferred).

    j. Each instrument should have characteristics including:

        1) Have its own double-pole power switch with indicating light and fuse.

        2) Be equipped with an indicator dial and chart recorder plug-in terminals on the front of the module.

        3) Have "power-on" and "in-service" lamps for visual display of the sensor status.

Layout of air monitoring facility:

1. Obtain list of all equipment to be included in the facility given in terms of make and model descriptions with installation instructions and dimensions.

2. List all support materials needed for the equipment to be used. Give special attention to utility requirements and storage of spare parts.

3. Estimate amount of workspace required in the facility.

4. Determine minimum space required for the conduct of all activities which are to be conducted within the facility.

5. Draw facility outline.

6. Layout instruments and analysis areas taking into account needs for water, access to air intake manifold, electrical current, exhaust requirements, etc.

7. Draw activity patterns on the initial layout.

8. Check to be certain that simultaneous activities do not interfere.

9. Check to be certain that easy access has been provided to all equipment and workspaces.

10. Finalize layout plan and submit to proper authority for approval.

Layout of a mobile van used for air monitoring:

1. Follow the procedure given for layout of air monitoring facility.

2. In addition, check the weight distribution on the wheels of the van to see that about 60 percent is to front of the wheels and about 40 percent to the rear.

3. Hook sanitary facilities in the van to local sewer system since holding tanks cannot be used due to the problems involved in venting.

4. Use local power sources to avoid the necessity of operating power generation equipment in the vicinity of the van.

5. Provide adequate environmental control to assure the necessary conditions for the instruments.

6. Locate the analyzers down the center of the van to allow easy access and to keep them away from the walls where temperature fluctuations are the greatest.

7. Provide adequate storage space.

8. Assure that the trailer meets local codes for the area in which it is to be used.

9. Provide facility for securing the instrumentation and other equipment during travel.

10. Provide good lighting and adequate workspace with phone conduits.

11. Assure stable power.

<u>Skill Requirements</u>

Establishment of design goals:

1. Ability to identify and describe uses for the AMF other than control and research.

2. Ability to suggest best location for facility given the stated purpose for creation of the AMF.

3. Ability to identify type and likely concentration range of pollutants which will be found at AMF site.

4. Ability to identify unusual environmental characteristics of the proposed AMF site.

5. Ability to identify social and political characteristics of the community which may impact the AMF design.

6. Ability to make design compensation in response to social political factors affecting AMF design.

7. Ability to determine if fixed, mobile, or multiple location monitoring is required, based on objectives and site characteristics.

8. Ability to document and communicate all findings and decisions in writing.

Selection of instruments and analytical methods to be included in facility:

1. Ability to specify all support materials, including utilities needed for the suggested hardware and measuring techniques.
2. Ability to weigh characteristics of the various instruments and rank order them in terms of their applicability for use in the specified AMF.
3. Ability to make trade-offs between desirability of instrument and cost.
4. Ability to write procurement specifications.

Layout of air monitoring facility:

1. Ability to specify all support materials, including utilities needed for the suggested hardware and measuring techniques.
2. Ability to estimate workspace requirements.
3. Ability to make engineering drawings.
4. Ability to draw facility outline.
5. Ability to layout equipment and analysis areas taking into account needs for water, access to an air intake manifold, electrical current, exhaust requirements, etc.
6. Ability to identify activity patterns.
7. Ability to assess access to equipment from engineering drawings.

Layout of mobile van used for air monitoring facility:

1. Ability to accurately estimate environmental control requirements for the van and to design a system which will fulfill the requirements.
2. Ability to estimate storage space requirements.
3. Ability to design techniques for securing instruments and other equipment during transport.

4. Ability to determine adequate lighting to meet standards of illumination which meet human engineering standards.

Knowledge Requirements

Establishment of design goals:

1. Knowledge of degree to which facility will be used to collect data for control purposes.
2. Knowledge of degree to which facility will be used to collect data for research purposes.
3. Knowledge of data storage and presentation format requirements.
4. Knowledge of minimum concentration levels of pollutants which must be detected.
5. *Knowledge of amount of money available for the construction* of the AMF.
6. Knowledge of legal restrictions affecting the selected site.
7. Knowledge of manpower availability near the proposed site.

Selection of instruments and analytical methods to be included in the facility:

1. Knowledge of each type of measurement to be made in the AMF.
2. Knowledge of all techniques which can be used to achieve the required measurements.
3. Knowledge of all commercially available hardware and materials which will support the desired measurements.
4. Knowledge of sensitivity requirement for the measurements.
5. Knowledge of sensitivity of the instrument including the validity and reliability of the obtained measurements.
6. Knowledge of the response time required to note change in environmental conditions after they have changed for each instrument.

7. Knowledge of the readability of the meters or recorders associated with each instrument.

8. Knowledge of the compactness and portability of each instrument.

9. Knowledge of the installation, operation procedures, and ease of maintenance for each instrument.

10. Knowledge of cost of procurement and operation of each device.

Layout of air monitoring facility:

1. Knowledge of all equipment to be used in facility.

2. Knowledge of appropriate channels for submission of final plans.

Layout of a mobile van used for air monitoring facility:

1. Knowledge of procedure for layout of air monitoring facility.

2. Knowledge of approximate weight of all equipment to be placed in van.

3. Knowledge that sanitary facilities in van must be hooked to local sewer system.

4. Knowledge that local power sources should be used, not self-generated power due to the production of contaminants in the area of the van.

5. Knowledge that analyzers should be located in the center of the van to keep them away from extreme temperature fluctuations along walls and to provide easy access.

References

1. Golden, J. & Mongan, T. R. Designing and air monitoring facility. Mechanical Engineering, August 1971.

2. Hamburg, F. C. Some basic considerations in the design of an air pollution monitoring system. Journal of the Air Pollution Control Association, October 1971.

3. Hickey, H. R., Rowe, W. D., & Skinner, F. A cost model for air quality monitoring systems. Journal of the Air Pollution Control Association, November 1971.

Special Staffing Guidance

The highly complex nature of this task requires not only a thorough and up-to-date knowledge of analytical chemistry analysis procedures and instrumentation but a solid understanding of the requirements that must be fulfilled by the AMF and the availability of agency resources. It would appear that the final responsibility for AMF planning must rest with a senior level Chemist although in practice many of the planning activities can be carried out by less senior Chemists under his direction.

Routine Forecast of Meteorological Conditions and Pollution Levels or Effects

Task Overview

The objectives of this type of task are to use descriptions of current or recent meteorological conditions (e.g., current inversion strength and height) and other parameters (e.g., time of the year, location of monitoring equipment) to forecast pollution-related meteorological conditions (e.g., inversion break time) and associated pollution characteristics (e.g., expected contaminant levels, anticipated effects, or acceptable/ unacceptable activities during the forecast period).

The forecasting operation requires a broad knowledge background in the areas of meteorology and the dynamics of air pollutants in the atmosphere. Judgments and decisions may be required, although objective forecasting systems are becoming effective and widely used. Also, there is a very real credibility requirement that demands a trained meteorologist for the task. This is particularly true when various activities (commercial, industrial, or private) can be legally curtailed as a result of the meteorologist's decision (e.g., "No Burn Days" in California).

The following task description is representative of the manner in which the task would be performed within a comprehensive State or local agency.

Occupational Category: Meteorologist

Task Description

The Meteorological Technician is responsible for collecting or assembling meteorological raw data and formatting it so that the Meteorologist can use it for forecasting. A representative version of the data assembly and format task is covered on Page E-96 of this volume.
The following description assumes that the Meteorological Technician has provided data describing an inversion, and the Meteorologist must forecast associated pollution conditions using this descriptive data.

1. Forecast time during coming period that inversion break temperature will be reached. Use historical data of daily temperature fluctuations, NWS forecasts, and facsimile maps.

2. Estimate strength of inversion which might occur 24 hours hence. Use NWS 850 mb charts and forecasted minimum surface temperature for period (i.e., NWS Max/Min Temperature forecast). Identify onset time of predicted inversion.

3. Forecast break time of predicted inversion using graphic techniques and knowledge of local wind and temperature variation. Use 500, 850 mb charts and surface map. Consider effects of fronts.

4. Predict average surface wind speed and direction (today and tomorrow). Accuracy should be to 0.5 m/sec. Use NWS Wind Facsimile, Wind Forecasts, and Projected Surface maps. Consider local wind speed/direction historical data, diurnal variations, and effects of predicted fronts, pressure systems. Use historical data from meteorological monitoring system.

5. Determine current and 24-hour-hence ventilation:

   a. Use forecasted high temperature for period and graphic methods to determine "mixing height."

   b. Predict average winds through mixing height (using radiosonde data) and calculate ventilation. Predicted ventilation (24 hour) is based on predicted inversion height.

6. Determine current vorticity advection into area.

7. Forecast air pollution levels from meteorological data using objective or subjective (predictive) relationships. For example, prediction of COHS from inversion strength and average morning and afternoon maximum wind velocity. References 1, 2, 3, and 4 provide descriptions of forecasting methods currently in use or under development.

Skill Requirements

1. Ability to use (identify, discriminate, interpret) appropriate information in the following formal data sources to forecast meteorological conditions. Forecasts are usually for morning and afternoon of the day for which the data is available and for the following morning. The types of meteorological conditions typically forecasted include:

    a. Inversion break temperature and time

    b. Inversion strength, base height, and type

    c. Mixing heights

    d. Maximum and minimum temperatures

    e. Surface wind velocity and direction

    f. Ventilation

    g. Visibility (mileage, restrictions)

    h. Precipitation

    i. Cloudiness (thickness, areal extent, duration)

    The formal data sources used in making the above forecasts include:

    a. Upper air charts (e.g., 500 mb, 850 mb)

    b. Surface charts

    c. High Air Pollution Potential Advisories (HAPPA)

    d. Hourly weather bureau reports

    e. Weather bureau, wind, max/min temperature forecasts and facsimiles

    f. Air Stagnation Narratives or Advisories

    g. Boundary Level Forecasts

    h. Historical records of local meteorological characteristics (e.g., diurnal cycles, seasonal variations)

    i. Upper air soundings for stations considered.

2. Ability to identify local topographical features which affect weather conditions and forecast their specific effects on meteorological conditions. Topographical features such as the following should be considered:

   a. Terrain (e.g., roughness, profile, valley width, proximity to large bodies of water)

   b. Vegetation (e.g., physical and dimensional characteristics)

   c. Urbanization (channeling effects, heat island effects, nighttime radiation)

   d. Hydrology (e.e., shape, size, dynamic properties of nearby water bodies)

3. Ability to interpret known stochastic relationships of meteorological conditions and pollution levels (e.g., regression equations, measures of central tendency and variance).

4. Ability to integrate information relevant to contaminant properties, source characteristics, and meteorological conditions to forecast contaminant levels for up to 24 hours from forecast point.

5. Ability to use graphic methods to determine inversion strength, height, and break temperature.

6. Ability to determine current ventilation rates using the appropriate NWS charts and teletype data.

7. Ability to forecast ventilation for a 24-hour period.

Knowledge Requirements

1. Knowledge of graphic procedures used to identify, describe, and forecast inversion characteristics (e.g., strength, height, break temperature).

2. Knowledge of the procedures for forecasting meteorological conditions relevant to air pollution control using appropriate data sources.

3. Knowledge of local historical and topographical effects (e.g., wind speed/direction records, diurnal temperature variations) which influence meteorological conditions and the associated effects on pollution levels.

4. Knowledge of the relevant properties of the pollutants (e.g., interaction with sunlight) and emission sources (e.g., location; emission output; emission patterns as a function of time, season, etc.) which interact with meteorological conditions to produce contamination levels.

5. Knowledge of the procedures for using objective (i.e., relatively mechanical) systems for predicting contamination levels from meteorological data.

6. Knowledge of the guidelines, criteria, rules of thumb, contingency plans, etc., used in subjective systems for predicting pollution levels from meteorological conditions.

7. Knowledge of the method for reading the vorticity chart.

References

1. Kauper, E. K. Problems associated with forecasting over an urban area. Air Quality Report No. 44. Los Angeles: Technical Services Division, Los Angeles County Air Pollution Control District, November 6, 1961.

2. Kauper, E. K., Hartman, D. F., and Hopper, C. J. Smog forecasting in the Los Angeles basin. Air Quality Report No. 37. Los Angeles: Technical Services Division, Los Angeles County Air Pollution Control District, September 1, 1961.

3. McFarland, D. G., Barry, E. V., & DeNardo, J. W. The development of a quantitative objective air pollution forecast system for Allegheny County, Pennsylvania. Paper presented at the 62nd Annual Meeting, Air Pollution Control Association, New York, June 22-26, 1969.

4. Wachtenheim, A., & Keith, R. W. Forecasting ozone maxima for Los Angeles County. Paper presented at the 62nd Annual Meeting of the Air Pollution Control Association, New York, Los Angeles County Air Pollution Control District, July 24, 1969.

Special Staffing Guidance

1. In a small (one or two person) meteorology unit, the individual responsible for forecasting pollution conditions should be a senior level person. The greater the extent of public exposure given to the Meteorologist's function, the more important is the need for a senior level individual. However, if public exposure can be reduced, a moderately experienced Meteorologist can be used for this operation.

   In larger meteorology units the individual doing the actual forecasting operation typically does not have to announce or defend his judgments. If a defense is required, his supervisor (a senior level Meteorologist) can handle that responsibility.

2. Another factor which governs the level of Meteorologist assigned to the forecasting task is the degree to which the forecasting system has been structured or standardized. In some agencies relatively objective forecasting systems are in use. These systems are not fully proceduralized, but do greatly reduce the number or difficulty of judgments required of the Meteorologist. Senior level individuals are required for subjective systems and to cope with contingencies which are not effectively treated by a structured forecasting system.

Assemble Meteorological Data and Describe Climatological Conditions

Task Overview

Many comprehensive agencies routinely collect meteorological data either through their monitoring system or from meteorological data services (e.g., National Weather Service, private consultants). This data is organized, analyzed, and then used to describe current or past conditions (e.g., inversions, wind patterns) as a basis for more complex activities such as forecasting pollution conditions. The task of assembling, manipulating, and then using the data for descriptive purposes is usually a proceduralized operation requiring a minimum of decision making and skill-demanding judgments.

The output of this task (a description of climatological conditions) may be used by agency personnel for tasks such as:

1. Prediction of pollution levels based upon current conditions.
2. Correlation with concurrent pollution conditions in order to develop predictive relationships.
3. Use in research projects.

The task description presented below is representative of the type of data assembly/analysis task observed in several agencies studied.

Occupational Category: Meteorological Technician

Task Description

1. Decode teletype record of NWS Radiosonde output (temperature, dew point, wind direction, and wind speed as a function of altitude).
2. Plot decoded data on appropriate chart paper (e.g., ATA chart 20 Skew T Diagram, ESSA Pseudo-Adiabatic Chart, or area surface map). Additional data such as aircraft soundings should be used when available.

3. Identify errors in printout (e.g., temperature less than dew point, unusually high or low values compared to other data). Estimate proper data points as a function of meteorological principles and evolving data patterns.

4. Recognize inversions aloft and at surface (including frontal and subsidence inversions).

5. Using graphic methods, determine inversion strength and height (i.e., from temperature by altitude plot of radiosonde data).

6. Using graphic methods and temperature records for previous period, determine inversion onset time.

7. Determine inversion break temperature using graphic methods (including dry adiabat lines and plotted data).

8. Plot, contour, or record descriptive data in appropriate format and submit to the Meteorologist for further analysis. In some instances, however, the data prepared by the Meteorological Technician can be submitted to the news media for public consumption if strictly descriptive information is required.

Skill Requirements

1. Ability to decode teletype transmissions rapidly and accurately (e.g., NWS, military circuit).

2. Ability to plot meteorological data in a format appropriate to the charting medium employed. Meteorological data such as the following are typically recorded:

   a. Temperature

   b. Dew point

   c. Wind velocity and direction

   d. Visibility (mileage and restrictions)

   e. Cloud conditions

   f. Pressure systems

Examples of the type of charting media typically employed are:

a. ATA Chart 20 Skew T Diagrams

b. ESSA (Dept. of Commerce) Pseudo-Adiabatic Chart

c. Area surface map

3. Ability to recognize errors in teletype printout (e.g., unreasonably high or low wind speed) and identify a "ball park" data point which is probable within the evolving data context and meteorologically plausible.

4. Ability to accurately extrapolate from temperature records to forecast inversion onset time. This behavior should only be considered as a skill if temperature records are incomplete enough to require extrapolation.

5. Ability to use graphic methods to determine inversion strength, height, and break temperature.

6. Ability to plot and contour meteorological data (e.g., isotherms, isobars).

Knowledge Requirements

1. Knowledge of procedure for decoding meteorological data transmissions (e.g., National Weather Service code for reporting daily radiosonde results).

2. Knowledge of the procedure for plotting meteorological data on a given recording medium (e.g., ATA Chart 20 Skew T Diagram). Also, knowledge of the methods used in contouring meteorological data (e.g., plotting isotherms or isobars).

3. Knowledge of the types of errors which can occur in meteorological data reported by NWS Radiosonde, the relative likelihood of their occurrence, and methods for estimating the proper data points as a function of meteorological principles and the evolving data patterns.

4. Knowledge of the data plot pattern for each of the types of inversions the meteorologist is required to recognize (e.g., frontal and subsidence inversions).

5. Knowledge of graphic procedures used to identify, describe, and forecast inversion characteristics (e.g., strength, height, break temperature).

Special Staffing Guidance

Tasks of this type should be supervised by a Meteorologist. The Meteorologist should train the Meteorological Technician to perform the task, provide quality control guidance as required, assist in handling contingencies (e.g., unusual printout errors), or demonstrate specialized techniques that might be needed.

Problem Solving Using Mathematical Models

Task Overview

One of the primary work areas for the Meteorologist is the estimation of ambient air conditions at surface points as a function of source emission characteristics and meteorological conditions. Several mathematical models are available which describe the interrelationship of these three phenomena. The types of problems meteorologists assist in solving with mathematical modeling include:

1. Determine the appropriate stack height for a new plant such that its emissions will produce a minimum effect on ambient air quality.
2. Identify source of an odor. Determine its path.
3. In the permit review process determine the downwind concentrations due to a particular source.
4. Evaluate the relative advantages of a "roll-back" type of control program as compared to a selective source-by-source control effort.
5. Determine whether implementation of a proposed source emission standard will result in ambient air quality which is in compliance with a specific standard.

The latter task will be described here in general terms as it is representative of the group and contains many of the underlying skills and knowledge required for the remainder of the list.

Occupational Category: Meteorologist

Task Description

For the purposes of this description it has been assumed that the required calculations are performed using a computer, and that programming and computer operations are not the responsibility of the Meteorologist.

1. Identify and secure all input data requirements from the model description and assumptions. Include data related to emission sources and their effluents, background concentration levels, wind and stability information, and the location of receptor sites on a grid system (e.g., the Universal Transverse Mercator System).

2. Review assumptions of the model and assure that input data to be used is appropriate. For example, point sources with tall stacks may have an effective stack height above a shallow mixing depth. Since it is assumed that the plume will not diffuse downward through the stable layer, these cases should be identified and eliminated from consideration.

3. Secure the required input data. Maximize data validity, reliability, and appropriateness for the model. For example, use a sounding to determine meteorological data required for stability judgments rather than subjective judgments made from surface observations.

4. Make auxiliary data manipulations such as the following (these may be made automatically by the computer):

   a. Develop stability-wind roses for areas covered by the model.

   b. Calculate effective stack heights.

   c. Modify receptor to source distances as required when area sources are treated as "effective point sources."

5. Process initial input data using the model. In most cases these calculations will be performed by a computer. However, if the scope of the problem is small enough a desk calculator could be used. Tables and graphs are available which aid "desk-top" data processing.

   The output of the model will be the annual arithmetic average ground-level pollutant concentrations resulting from specified point and area sources under specific meteorological conditions.

6. Calibrate the output of the model. This is accomplished by correlating the calculated concentration values for specific

receptor sites with the actual observed (i.e., measured) levels for those sites. A least-square regression line is plotted. If the correlation coefficient is statistically significant (e.g., at the .05 level) then the regression equation is used to "fine tune" the concentrations produced by the model for all sites.

If the correlation coefficient is not significant the input data (e.g., emission inventory, meteorological data, and observed concentration) should be revised. If the correlation cannot be improved, the model's assumptions should be reviewed to determine how the data should be improved.

7. Process complete input data using the model.

8. Convert output data as required for any specialized uses. For example, the Meteorologist might desire to describe the distribution of concentrations in terms of the geometric mean and geometric standard deviation, rather than the arithmetic mean. He might also want to determine the expected maximum concentration for each receptor in the analysis. Procedures are available for these types of conversions.

9. Prepare output data as required to interpret findings. For example, calculated concentrations can be plotted on a surface map (i.e., using isopleths) and compared with the required ambient standard.

10. Report findings in written form as a technical report, or possibly make an oral report.

Skill Requirements

1. Ability to use nomographs, tables of data, special slide rules, desk calculators, and other aids in performing required calculations or data determinations.

2. Ability to select a mathematical modeling method which is appropriate to a specific problem for which the required raw data is accessible, and for which the appropriate data processing resources (men and machines) are available.

3. Ability to carry out all of the steps in a mathematical modeling procedure accurately and completely. This skill is primarily one of integrating and effectively using all of the information available and in the manner prescribed by the model.

4. Ability to communicate effectively, orally and in writing, with technical personnel whose knowledge and abilities are required for solution of problems using mathematical modeling. For example:

   a. Computer programmers and operators.

   b. Engineers with knowledge of the emission inventory and emission source characteristics.

   c. Pollution control strategists or engineers who have submitted the problem to the Meteorologist for solution and who have a need to know the results.

   d. Air monitoring staff who provide the data required to calibrate the model.

   e. Statisticians or operations researchers who may be required to answer questions or otherwise provide support in the problem-solving effort.

5. Ability to accurately recognize and interpret the effects of factors such as the following on the usefulness of the results of mathematical modeling effort:

   a. The model's theoretical and practical limitations (such as the adequacy of the assumptions, tacit and explicit, imposed by use of the model).

   b. The adequacy of the raw data (e.g., the range of values used for calibration).

6. Ability to translate general descriptions of mathematical modeling methods into specific techniques useful for solving specific problems.

7. Ability to recognize problems for which mathematical models are appropriate and cost-effective means of solution.

8. Ability to use the results of the modeling effort to solve the problem for which the model was employed.

9. Ability to determine how and when the output of the model should be modified to suit the current use of the data.

10. Ability to prepare an accurate and complete report of the modeling effort in terms of methods, assumptions, outcomes, and need for further investigation in order to solve the problem of concern.

11. Ability to systematically and effectively solve problems or make decisions. This general skill includes:

    a. Ability to accurately define the problem in terms of objective, desirable outcome.

    b. Ability to accurately and completely identify the elements of the situation which affect selection or development of a solution.

    c. Ability to identify and describe potential solutions or approaches for developing solutions.

    d. Ability to accurately define the relationships between these elements and the alternative solutions to the problem. This includes "trade-offs."

    e. Ability to set realistic priorities.

    f. Ability to estimate with a reasonable level of confidence the probabilities of successful solution for each alternative solution.

    g. Ability to maximize positive payoff by selecting the most effective and least costly solution.

    Tasks requiring this ability often may have to be accomplished under a high degree of time stress and under public scrutiny.

12. Ability to accurately evaluate the validity, reliability, and usefulness of input data used in mathematical modeling. This skill includes making modifications to the model or data to correct for or accommodate weaknesses in the data input.

13. Ability to make auxiliary data manipulations in mathematical modeling. Such data manipulations include:

    a. Stability-wind roses.

    b. Effective stack height calculations.

    c. Receptor to source distance modifications when area sources are treated as "effective point sources."

14. Ability to accurately carry out and interpret statistical calibration procedures on mathematical model output.

15. Ability to accurately complete and interpret required modifications to mathematical model output (e.g., transformation of concentrations to geometric means and geometric standard deviations).

16. Ability to determine manner in which output of mathematical modeling procedure should be presented to best answer the original problem (e.g., plotting resultant concentrations on an appropriate surface map).

Knowledge Requirements

1. Knowledge of the uses, assumptions, and procedures of mathematical models of pollution diffusion. For examples of resource materials in this area see References 1, 2, 7, 8, 9, 11, and 12.

2. Knowledge of the inadequacies of a selected mathematical model such that interpretation of its output can be made as validly as possible. The following are representative limitations in the frequently used model which the meteorologist should be aware of in interpreting his findings:

    a. Climatological data used in model calculations should be secured from receptors in the area to which the model is to be applied. Frequently, this data is obtained from airport observing stations located in areas with significantly different climatological conditions than an urban central area.