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

VOLUME F
Detailed Task Data, and Staffing Guidance
SOURCE TESTING

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
Manpower Development Staff   Office of Air Programs
Research Triangle Park, North Carolina 27711

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INTRODUCTION

One of the pressing problems in the air pollution control effort at Federal, state, and local levels is planning manpower requirements and developing manpower resources. Questions are being asked such as, how many people are needed, what kind of past experience and education should they have, how should their jobs be structured, what do they need to know to do their jobs, what special abilities do they need, and what kind of training should they receive to do their jobs? These questions are becoming increasingly meaningful as the control effort broadens with the creation of more and more local agencies and as existing agencies increase the scope and depth of their programs. Adequate answers are required if progress is to continue toward the goal of clean air.

In order to begin to answer questions relevant to manpower planning and development, a data base describing the tasks to be performed by control agency personnel and the skills and knowledge they must have to perform those tasks effectively must be available. Guidance concerning the use of the data base in making staffing decisions must be prepared. It is the purpose of this study to provide such a data base and the appropriate guidance.

A. Objectives

The objectives of this project were the following:

1. To identify as great a proportion as possible of the population of tasks currently being performed by air pollution control agency personnel at the state and local level throughout the country.
2. To describe the identified tasks in terms of component behaviors and the skills and knowledge required to perform those behaviors.
3. To identify and describe categories of air pollution control agency personnel who would perform the tasks mentioned above.

continued

4. To structure and communicate the data which resulted from achieving the above objectives in a form which could be used by agency management in planning and developing manpower resources.

B. General Project Overview

The project was performed in two phases. Phase I dealt with achieving the first two project objectives, and resulted in the development of a detailed data base describing the major tasks performed by agency personnel in terms of the procedural components of the tasks and the skills and knowledge required to perform them. Phase II dealt with achieving the last two major objectives, and resulted in production of a guidance document which integrates and structures data developed in Phase I and presents it in a form designed to assist agency manpower developers.

THIS IS VOLUME F
Additional books available are:

VOLUME A: Guidance and Supporting Information for Staffing and Training Decisions in an Air Pollution Control Agency - Introduction and Directions for Using These Guidelines

VOLUME B: Guidance and Supporting Information for Staffing and Training Decisions in an Air Pollution Control Agency - Engineering

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SOURCE TESTING

The task data and staffing guidance presented in this volume cover tasks which are generally performed by Engineers or Equipment Technicians in connection with the agency's source testing effort. The tasks included in this volume deal with both stationary and mobile sources.

This volume covers the following source testing activities:

1. Performance of a Stack Test — Page F-3
2. Managing a Stack Test — Page F-10
3. Determination of Odor Concentration in the Atmosphere or in Stack Emissions — Page F-19
4. Performing a Used Car Inspection — Page F-23
5. Performing the Idle and ACID Tests — Page F-27
6. Planning the Dynamometer Installation — Page F-30
7. Operation and Maintenance of the Engine Dynamometer — Page F-35
8. Operation and Maintenance of the Chassis Dynamometer — Page F-42

Performance of a Stack Test

ask Overview

here are more variations of stack testing methods than there are air ollution control agencies. Some variations result from different :inds of testing situations; others appear to be a function of the xperience of individual stack testers. Basically, however, all stack :ests for particulate and/or gaseous concentration follow the general procedure that is briefly described below:

1. Measurement of the gas flow. A stack test must be performed isokinetically, that is, the sampling rate must equal the rate of flow of the stack gas. Therefore, before a sample is collected the gas flow must be measured. This includes determining the gas velocity; the static pressure inside the stack; and the temperature, moisture content, and density of the gas.

2. Assembly and operation of the sampling train. The sampling train must contain the following elements:

   a. Sampling nozzle.

   b. Particulate sample collection device (e.g., impinger, filter).

   c. Gas sampling device (e.g., absorber).

   d. Sampling probe.

   e. Condenser or moisture trap.

   f. Gas meter for measuring volume of sample.

   g. Pump, or some other air-moving device.

   h. Appropriate temperature and pressure indicators.

   There are many possible variations within the basic structure of this train but this activity requires assembling the train according to plan using laboratory prepared impingers and dry collectors, determining sampling nozzle size and sampling flow rate and conducting the mpling procedure as planned. Isokinetic conditions must be maintained throughout the test and all test parameters must be periodically monitored and recorded.

3. Returning sampling apparatus and data records to the laboratory for analysis.

Occupational Category: Equipment Technician

Task Description

The skill and knowledge analysis of this task is based on a conglomeration of all of the variations encountered in the air pollution control agencies. However, each of these variations is also contained in one or more of the task descriptions presented in the publications cited at the end of this analysis (References 1, 2, 4, 5, 6, 7, 10, and 11). The remainder of the publications listed (References 3, 8, and 9) contain useful information with regard to stack testing equipment and selected testing techniques.

Skill Requirements

1. 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.
2. 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.
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 quickly and correctly solve an algebraic equation' in several unknowns using a detailed step-by-step procedure. Such equations include:
   a. Calculating the concentration of a pollutant given the sample absorbance reading and the calibration curve.

b. Converting the volume of gas samples to the volume at standard temperature and pressure using the perfect gas equation.

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

6. Ability to accurately read, operate, calibrate, and otherwise maintain the instruments required for measuring the velocity pressure, static pressure, temperature, moisture content, and composition of stack gases. (See Knowledge 3 for a complete list of instruments).

7. Ability to quickly and accurately perform calculations of the type which must be performed during a stack test; for example, the calculation of the meter rate and sampling nozzle size.

Knowledge Requirements

1. Knowledge of the apparatus required for the task and how it is configured.

2. Knowledge of the task procedure with all steps in their proper sequence.

3. Knowledge of the nomenclature, configuration, and use of instruments including:

    a. Pitot tube (standard)

    b. Type S pitot tube

    c. Inclined manometer

    d. Draft gauge

    e. Micromanometer

    f. Thermo-anemometer

    g. Vane anemometer

    h. Thermocouple and potentiometer

    i. Mercury bulb thermometer

j. Water gauge manometer

k. U-tube mercury manometer

l. Condenser

m. Wet- and dry-bulb thermometers

n. Orsat apparatus

4. Knowledge of the nomenclature, configuration, and use of the apparatus required for collecting a stack gas particulate and gaseous samples, including:

   a. Sampling nozzle, e.g., gooseneck nozzle

   b. Alundum thimble and holder

   c. Flat filters and holders

   d. Glass wool filter tube

   e. Sampling probe

   f. Condenser

   g. Dry test meter

   h. Gas flowmeter

   i. Orifice meter

   j. Rotameter

   k. Pumps, e.g., rotary positive displacement pump

   l. Aspirator

   m. Impingers (Smith-Greenberg type)

   n. Thermometers

   o. Pressure gauges, e.g., manometer

   p. Paper thimble and holder

5. Knowledge of the procedure for conducting a velocity traverse.

6. Knowledge of the techniques for marking a pitot tube or sampling probe in order to position the tube or probe at each of the sampling points.

7. Knowledge of the procedure for grounding a pitot tube (or sampling probe) in the case of sampling near an electrostatic precipitator.

8. Knowledge of the proper technique for measuring the temperature of stack gases.

9. Knowledge of the procedure for measuring the static pressure inside a stack.

10. Knowledge of the procedure for calculating the absolute pressure of a stack, given the static pressure of the stack and the barometric pressure.

11. Knowledge of the procedure for determining the moisture content of stack gases, using either a condenser or wet- and dry-bulb thermometers.

12. Knowledge of precautions that must be taken with regard to hazards, such as platform height, high temperature of stack and gases, and electrical charges.

13. Knowledge of the procedure for conducting the stack sampling. This includes knowledge of the technique for:

    a. Inserting the probe.

    b. Operating sampling apparatus.

    c. Moving the probe from one point to another.

    d. Recording times, temperatures, pressures, meter rates, etc.

    e. Removing the probe without losing any of the sample.

14. Knowledge of procedure for draining the sampling train of moisture and measuring the condensate.

15. Knowledge of the procedure for calculating the size of the sampling nozzle required.

16. Knowledge of the service, maintenance, and calibration requirements of all stack test instruments normally employed.

References

1. American Society for Testing and Materials. Standard method for sampling stacks for particulate matter. Philadelphia: Author, 1971. D2928-71.

2. American Society of Mechanical Engineers. Determining dust concentration in a gas stream. New York: Author, 1957.

3. Committee on Industrial Ventilation. Industrial ventilation. A manual of recommended practice. Lansing, Michigan: American Conference of Governmental Industrial Hygienists, 1970 (11th Edition). pp. 9(1-8).

4. Devorkin, H., Chass, R., Fudurich, A., & Kanter, C. R. Holmes (Ed.) Air pollution source testing manual. Los Angeles: Air Pollution Control District, Los Angeles County, November 1965.

5. Environmental Protection Agency. Standards of performance for new stationary sources. Federal Register, Volume 36, Number 159, August 17, 1971.

6. Haaland, H. H. (Ed.) Methods for determination of velocity, dust and mist content of gases. Bulletin WP-50. Seventh Edition. Los Angeles: Western Precipitation Division/Joy Manufacturing Company, 1968.

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8. Joy Manufacturing Company, Western Precipitation Division. Gas velocity and dust determination equipment. Catalog GV22. Los Angeles: Author.

9. Kimura, G. Emission control of flue-fed incinerators by use of air pollution control devices. Chicago: Department of Air Pollution Control, City of Chicago, November 1969. pp. 87-90.

10. PEDCo-Environmental Specialists, Inc. Administrative and technical aspects of source sampling for particulates. Contract No. CPA 70-124. Research Triangle Park, North Carolina: Environmental Protection Agency, May 1971.

11. Weisburd, M. (Ed.) Air pollution control field operations manual. A guide for inspection and enforcement. Washington, D. C.: U. S. Department of Health, Education, and Welfare; Public Health Service, Division of Air Pollution, 1962. PHSP #937. pp. 167-176.

Managing a Stack Test

Task Overview

Managing a stack test is usually an engineering function although, since the test usually involves the laboratory analysis of gaseous and particulate pollutants, a chemist may participate in test planning. The general procedure for managing a stack test is as follows:

1. Obtain the cooperation of plant personnel. This involves eliciting voluntary cooperation from high level management for the conduct of the test and collecting information about the industrial process being tested.

2. Plan the test. Information concerning the industrial process is used to determine such things as sampling location, number and configuration of sampling points, chemical analyses required and analysis methods to be employed, the design of the sampling train, personnel required, and when the test is to be performed.

3. Supervise the conduct of the test. During the test the planner is responsible to see that the plan is properly carried out and a reliable and valid test is conducted. This may involve training and providing on-the-job guidance for junior level personnel and evaluating their performance. Another function of the planner in this step is to assure that the industrial process is operating as it typically would.

4. Analyze the results of the test. Once all parameters have been measured, either directly or via laboratory analysis, the results must be evaluated. A report is then written appropriate to the purpose of the test.

Occupational Category: Engineer

Task Description

The skill and knowledge analysis of this task is based on a conglomeration of all of the variations encountered in the air pollution control agencies. However, each of these variations is also contained in one or more of the task descriptions presented in the publications cited at the end of this analysis (References 1, 2, 4, 5, 6, 7, 10, and 11). The remainder of the publications listed (References 3, 8, and 9) contain useful information with regard to stack testing equipment and selected testing techniques.

Skill Requirements

1. Ability to effectively communicate and cooperate with plant personnel.

2. Ability to select the sampling location based on the following optimal conditions:

    a. Distance of at least eight stack diameters downstream and two diameters upstream of any obstructions, e.g., bends, fans, vents.

    b. Vertical rather than horizontal duct.

    c. Ample room for test personnel and apparatus.

    d. Access to electrical power.

3. Ability to establish the number of required sampling points according to the following criteria:

    a. Proximity of the sampling location to any stack conditions which might cause abnormal particulate stratification.

    b. Size and shape of the stack.

    c. Gas velocity, volume, and turbulence.

4. Ability to design a sampling train which is appropriate for a specific test with regard to the following criteria:

    a. Stack temperature

    b. Particle size

    c. Moisture content of gas

d. Corrosive nature of the gas

e. Type of analysis to be performed

5. Ability to calculate a reasonable estimate of the total amount of moisture expected to be condensed from the gas sampled.

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

7. 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.

8. Ability to make work assignments and coordinate the efforts of all personnel performing the stack test.

9. Ability to develop work procedures which provide detailed step-by-step guidance in the performance of the stack test.

10. Ability to document all procedures, findings, ideas, and decisions in writing which communicates clearly and completely to the intended audience.

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

12. Ability to cooperate with laboratory personnel in planning tests so as to assure proper coordination of analysis and sample collection activities.

13. 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 sampling train.

Knowledge Requirements

1. Knowledge of the procedure for obtaining information about the process which produces the stack gases. Important information might include:

   a. Cyclic or steady state nature of the process

   b. Feed composition and rate

   c. Fuel rate

   d. Gas volume

   e. Operating temperatures and pressures

   f. Toxic conditions

   g. Schedule of operation

   h. Control equipment

   i. Expected type of emission

   j. Stack dimensions

2. Knowledge of the effects on stack gas particulate concentration resulting from each of the following stack characteristics:

   a. Changes in direction

   b. Horizontal duct

   c. Fans

   d. Vents

   e. Change in the shape of the stack

3. Knowledge of the procedure for subdividing a circular or rectangular stack cross section into a given number of equal area zones.

4. Knowledge of the procedure for calculating the equivalent diameter of a rectangular stack.

5. Knowledge of the factors which determine the selection of either a standard or type S pitot tube for performing a velocity traverse.

6. Knowledge of the procedure for determing the correction factor for a type S pitot tube.

7. Knowledge of the criteria for selecting a pressure-measuring device for obtaining the velocity pressure of a particular stack.

8. Knowledge of the proper technique for measuring the temperature of stack gases, including knowledge of the criteria for selecting the most appropriate measuring device.

9. Knowledge of the procedure for determining the moisture content of stack gases, using either a condenser or wet- and dry-bulb thermometers.

10. Knowledge of the procedures for calculating the following stack gas parameters:

    a. Average molecular weight.

    b. Specific gravity.

    c. Average gas velocity.

    d. Gas flow rate.

    e. Gas flow rate, corrected to standard conditions of temperature and pressure.

    f. Average gas velocity, based on change measured at one traverse point.

11. Knowledge of the procedure for calculating the expected sample weight.

12. Knowledge of the capacity, applicability, and advantages of different types of vacuum-producing devices, including a variety of pumps, blowers, and aspirators.

13. Knowledge of the procedure for calculating the proper sampling rate in order to achieve isokinetic sampling. The equation for this calculation compensates for the change in temperature, pressure, and moisture content of the gas as it passes from the stack through the sampling train to the meter.

14. Knowledge of the information required and presentation format for reporting the results of a stack test.

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

16. Knowledge of the test procedures, apparatus, and calculations for all variants of the stack test normally performed.

17. Knowledge of the theoretical background for the test procedures and apparatus of concern.

18. Knowledge of each source which is pertinent to identifying stack test methodology, its use and location.

19. 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

20. Knowledge of the stack test procedure sufficient to:

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

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

        1) Errors are known to frequently occur

        2) Little margin for error exists

        3) Errors are likely to go undetected

    c. Revise the procedue so as to reduce the possibility of error.

21. Knowledge of the chemical, electrical, and mechanical principles of operation of the various stack test 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.

22. Knowledge of the sampling procedures for determining the chemical composition (percent CO_2, CO, O_2, and N_2) of stack gas.

23. Knowledge of the procedure for calculating the expected sample weight.

24. Knowledge of the procedure for selecting an appropriate filtering media, given the expected sample weight, stack temperature, and the moisture content of the gas.

25. Knowledge of the efficiency, use restrictions, advantages, and disadvantages of each type of filtering media.

References

1. American Society for Testing and Materials. Standard method for sampling stacks for particulate matter. Philadelphia: Author, 1971. D2928-71.

2. American Society of Mechanical Engineers. Determining dust concentration in a gas stream. New York: Author, 1957.

3. Committee on Industrial Ventilation. Industrial ventilation. A manual of recommended practice. Lansing, Michigan: American Conference of Governmental Industrial Hygienists, 1970 (11th Edition). pp. 9(1-8).

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11. Weisburd, M. (Ed.) Air pollution control field operations manual. A guide for inspection and enforcement. Washington, D. C.: U. S. Department of Health, Education, and Welfare; Public Health Service, Division of Air Pollution, 1962. PHSP #937. pp. 167-76.

Special Staffing Guidance

The Engineer assigned to this task must possess all the skills and knowledge of the Equipment Technician(s) actually performing the stack test (see Page F-3).

In addition, he must have the theoretical background necessary to design test procedures and modify them to meet contingencies, administrative skills necessary for coordinating technical personnel in the conduct of the test, the ability to communicate clearly, verbally and in writing, and sufficient formal education to permit him to act as a credible representative of the agency when interacting with high level plant personnel. These requirements suggest the need for at least a Bachelor's Degree in an engineering field (e.g., industrial or chemical engineering) with experience working on a stack test team.

Determination of Odor Concentration in the Atmosphere or in Stack Emissions

Task Overview

Several different methods have been proposed and studied for measuring odor concentrations. These include both objective and subjective methods. Among the objective methods, as they are described in Reference 4, are:

1. Adsorption on activated carbon
2. Oxidimitric method
3. Chemical methods

For the most part, these methods have not been well enough developed to account for the complex interactions of many gas constituents in the development of odors.

All of the subjective methods rely on the human olfactory perception of successively diluted odor samples. The differences among the methods lie in the various techniques used for diluting the sample. Some of the subjective techniques are described in Reference 4 and elsewhere (as noted):

1. Syringe dilution method (see References 1 and 2)
2. Osmo method
3. Flow dilution method
4. Nader method
5. Scentometer method (see Reference 5)

At present, it appears that the syringe dilution method is the technique predominantly employed by air pollution control agencies. Briefly, the procedure is as follows:

1. An odor panel is selected, using an odor test in order to eliminate people with poor olfactory capabilities.
2. A sample is taken from a stack or the atmosphere with a syringe.
3. The sample is diluted and transferred to dilution syringes.

4. Panel members observe the diluted sample and report whether or not they can detect an odor.
5. The odor concentration is calculated at threshold of odor perception of at least 50 percent of the odor panel.

Occupational Category: Equipment Technician

Task Description

The procedure for this method of determining odor concentration is presented in usable form in Reference 2.

Skill Requirements

1. Ability to accurately prepare the solutions required for the "triangle" test.
2. Ability to clean the syringes and needles such that they will be odor-free.
3. Ability to use a soldering iron and silver solder to join the two components of a transfer needle.
4. Ability to accurately transfer definite volumes of the odor sample from one syringe to another.
5. Ability to determine the average velocity of discharge from a stack, using a method similar to that described in Reference 3.

Knowledge Requirements

1. Knowledge of the definition of and the procedure for calculating each of the following terms:
    a. Odor unit
    b. Odor concentration
    c. Odor emission rate
2. Knowledge of the concept of absolute thresholds.

3. Knowledge of the nature of possible interferences with valid odor measurement. These include:
    a. Extraneous odors and lingering taste effects
    b. Poor physical condition of observer
    c. Poor olfactory capabilities of observer
4. Knowledge of the procedure for preventing each interference, including the procedure for conducting a "triangle" test for panel selection.
5. Knowledge of the nomenclature, configuration, and principles of operation of the apparatus required for performance of the task:
    a. Luer type hypodermic syringe
    b. Transfer needle
    c. Syringe cap
6. Knowledge of the techniques for constructing a transfer needle.
7. Knowledge of the following procedures:
    a. Procedure for acquiring the odor sample.
    b. Procedure for preparing dilution samples.
    c. Procedure for administering the diluted sample to the observer.

References

1. Benforado, D. M., Rotella, W. J., and Horton, D. L. Development of an odor panel for evaluation of odor control equipment. Journal of the Air Pollution Control Association, Vol. 19, No. 2, February 1969, pp. 101-105.
2. Fox, E. A., and Gex, V. E. Procedure for measuring concentration in air and gases. Journal of the Air Pollution Control Association, Vol. 7, No. 1, May 1957, pp. 60-61.

3. Haaland, H. H. (Ed.) Methods for determination of velocity, volume, dust and mist content of gases. Bulletin WP-50. Seventh Edition. Los Angeles: Western Precipitation Division/ Joy Manufacturing Company, 1968.

4. Jacobs, M. B. The chemical analysis of air pollutants. New York: Interscience Publishers, Inc., pp. 369-386.

5. Ward, F. R. Odor measurement with the scentometer. Norfolk, Virginia: Odor Control Subcommittee, Industrial Standards Subcommittee, Industrial Standards Committee, National Renderers Association.

Special Staffing Guidance

1. Because this task has relatively few skill and knowledge requirements it can be performed effectively by a junior level Equipment Technician.

2. This task and the operation of the smog chamber could be assigned to the same Technician since both involve recruitment and testing of human subjects, although there is otherwise little skill and knowledge overlap between the two tasks.

Performing a Used Car Inspection

Task Overview

There are a variety of inspection techniques designed to identify automobiles producing excessive emissions. There are likewise variations among procedures for performing inspections using a given technique, e.g., the Idle test (see Page F-27). Further, inspections can be performed on all motor vehicles within an area or on a sample. The procedure presented here is representative of the equipment inspection technique in which idle speed, timing, and emission control equipment are checked for compliance with manufacturers' specifications. In this variant, only a sample of cars and used car lots are inspected. The task is performed by two-person teams.

Occupational Category: Equipment Technician

Task Description

The inspection team arrives at the used car lot without forewarning the manager at some time after sending him a letter explaining the inspection program.

1. The inspection team leader identifies the inspection team and elicits the voluntary compliance of the used car lot managers.
2. The other team member (the inspector) counts the cars on the lot and selects 10 percent at random for inspection. (Current model year autos are usually not inspected).
3. The team leader locates specification sheet for first car to be inspected while the inspector attaches tachometer, dwell meter and timing light to the car.
4. Car is started and permitted a short warmup (about three minutes).
5. Idle speed, dwell, and timing are read by the inspector and recorded by the leader who compares them to the specifications.

6. The inspector tests the PVC valve using a PVC valve tester and examines the condition of all emission control linkages, valves, dashpots, solenoids, tubing, and wiring to be sure that they are operational. His findings are recorded by the leader and compared to specifications.

7. The engine is stopped, equipment disconnected, and the team moves to the next car to be inspected.

8. The procedure is repeated until all cars selected have been inspected.

9. The used car lot manager is immediately given or sent written notification of the test results within a few days following the inspection.

Skill Requirements

1. Ability to communicate effectively with used car lot managers.

2. Ability to determine the make, model, and year of each auto to be inspected.

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

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

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

6. 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.

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 trouble-shooting charts.

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

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 task procedure with all steps in their proper sequence.

2. Knowledge of the procedure making random selection of autos to be inspected.

3. Knowledge of the procedures for attaching and operating the tachometer, dwell meter, timing light, and PCV valve tester.

4. Knowledge of the type of emission control equipment to be expected on each auto as a function of its make, model, and year.

5. Knowledge of the procedure for determining the manufacturer's recommended specification for idle speed, dwell, timing, and the operation of all emission control equipment.

6. Knowledge of the function and location of each operating and adjustment control on the test instruments.

Special Staffing Guidance

1. Because of the need for the leader of the inspection team to interact with car lot managers as a representative of the agency, the person assigned to this position should have a good understanding of the purposes and procedures of the inspection program and of general

agency organization, functions, authority and policies. This requirement suggests the need for at least a senior level Equipment Technician with several years of experience in the agency.

2. Because of the present lack of comprehensive highly proceduralized documentation covering inspection of auto emissions control equipment, the inspector must have an understanding of the basic principles of operation of the various general types of emission control devices. This suggests the need for an Equipment Technician with previous training in mechanical physics, chemistry and the theory of operation of the internal combustion engine. Relatively extensive training either on-the-job or formal will then be required to prepare this person for the inapection task. For example, one formal course available through Sun Electric Company requires one month of study.

Performing the Idle and ACID Tests[1]

Task Overview

The Idle and ACID tests are two techniques commonly used to measure hydrocarbon and carbon monoxide emissions from motor vehicles. The Idle test, being the simpler of the two, can be included within the discussion of the ACID test.

The ACID test requires the use of a chassis dynamometer and involves operating the vehicle in four modes for about 15 seconds each:

1. 0-30 MPH acceleration
2. 30 MPH cruise
3. 30-0 deceleration
4. idle

Constant inertia and power settings specific to the vehicle being tested are preset into the dynamometer. The entire exhaust is collected and CO analysed by the nondispersive infrared technique (see Reference 3). Hydrocarbons are measured by a flame ionization technique.

The Idle test involves simply testing the vehicle at idle using an analyzer such as the infrared exhaust emission tester described in References 3 and 4. Assuming the vehicle is at operating temperature the test requires about 35 seconds. No dynamometer is required.

Occupational Category: Equipment Technician

Task Related Material

Additional information relevant to the conduct of the ACID test can be found in Reference 2; information concerning the Idle test can be found in Reference 1.

[1] The task data reported here is incomplete; however, it is considered to be highly indicative of the actual task characteristics and skill and knowledge requirements.

Skill Requirements

1. Ability to operate the chassis dynamometer.
2. Ability to operate the emissions test instrumentation.
3. Ability to maintain vehicle speed and vary speed smoothly and at the rate required by the test procedure.
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.

Knowledge Requirements

1. Knowledge of the ACID test procedure.
2. Knowledge of the Idle test procedure.
3. Knowledge of the procedure for determining the dynamometer power and inertia settings given the vehicle to be tested.
4. Knowledge of the function and location of each operating and adjustment control on the test instrument(s).
5. Knowledge of the name and location of the various component parts of the test instrument(s).

References

1. Andreatch, A. J., Elston, J. C., and Lahey, R. W. Motor vehicle tune-up at idle. Trenton, New Jersey: New Jersey Department of Environmental Protection.
2. Elston, J. C., Andreatch, A. J., and Milask, L. J. Reduction of exhaust pollutants through automotive inspection requirements--the New Jersey REPAIR project, International Clean Air Conference on Air Pollution, Washington, D. C., February 1971.

3. State of New Jersey. Specification for exhaust gas analytical system. Trenton, New Jersey: Author, February 15, 1972.

4. Sun Electric Corporation. Infra-red exhaust emission testing handbook. Chicago, Illinois: Author.

5. Sun Electric Corporation. Product technical data and specifications--infra-red exhaust emission tester, Model EET-910. Chicago, Illinois: Author.

Special Staffing Guidance

Performing the tests themselves is relatively simple once the Equipment Technician knows how to operate the chassis dynamometer and/or the emissions test instrumentation. The Idle test requires a minimum of skill and knowledge, assuming that instrumentation similar to the Sun EET-910 (Reference 4) is employed, and can be effectively performed by an inexperienced junior level Equipment Technician. The ACID test is more complex and probably should be performed by the senior level Equipment Technician assigned to operate and maintain the chassis dynamometer (see Page F-42).

It is important that the assignees for this task be able to effectively communicate with the public and able to clearly describe the nature of the tests performed and the meaning of the results.

Planning the Dynamometer Installation[1]

Task Overview

Because of the large amount of physical space and site preparation involved in the installation of either the chassis or engine dynamometers, planning the installation deserves consideration as a task by itself. Basically, planning entails choosing a site within the shop or laboratory facility and designing the installation to facilitate hook-up of utilities and the movement of autos or engines on and off the device and to provide adequate working room for personnel.

Occupational Category: Engineer

Task Related Material

Material which provides information relevant to planning dynamometer installations can be found in References 1 and 2.

Skill Requirements

1. Ability to plan the installation of the chassis dynamometer including:

   a. Determining the design of the installation through identifying and coordinating the important design variables including:

      1) The space and construction characteristics and limitations of the installation site.

      2) The kinds of testing that will be performed using the dynamometer.

      3) Utilities requirements.

      4) Human engineering requirements.

[1]The task data reported here is incomplete; however, it is considered to be highly indicative of the actual task characteristics and skill and knowledge requirements.

5) Safety considerations.

6) Maintenance and servicing requirements.

7) Equipment, spare parts, and materials storage requirements.

b. Reading and producing engineering drawings and blueprints.

c. Reading and understanding local plumbing and electrical codes.

2. Ability to plan the installation of the engine dynamometer including:

a. Determining the design of the installation through identifying and coordinating the various design variables including:

1) The space and construction characteristics and limitations of the installation site.

2) The kinds of testing that would be performed.

3) Utilities requirements (e.g., cooling water flow and temperature, electricity).

4) Human engineering requirements.

5) Safety considerations

6) Maintenance and service requirements.

7) Equipment, spare parts, and materials storage requirements.

b. Reading and producing engineering drawings and blueprints.

c. Reading and understanding local plumbing and electrical codes.

<u>Knowledge Requirements</u>

1. Knowledge required to plan the installation of a chassis dynamometer including:

a. The space requirements for the installation based on the amount and size of equipment (e.g., the vehicle cooler and required test equipment) and the size of the vehicles to be tested.

b. How to determine the best location for device to minimize engine noise to other areas, out of normal shop traffic flow.

c. Necessary service facilities characteristics:

   1) Cooling and load water supply can be either domestic or industrial, temperature not in excess of 80°F, line pressure between 30 and 80 PSI, ideal pH is 9.

   2) Cooling and load water disposal must have a minimum of back pressure not to exceed one PSI.

   3) Electrical supply of 115 volts A.C.

d. Local plumbing and electrical codes.

e. Floor thickness (top floor mount).

f. How to determine the stability of earth over which dynamometer is to be installed (must be 2,000 lbs./sq. ft.) (flush mount).

g. Techniques for determining compressive strength of concrete (flush mount).

h. How to determine the best type of installation, i.e., back-on drive-off, or drive-on back-off.

i. Procedure for dynamometer chassis installation.

j. Procedure for connecting utilities and instrumentation to dynamometer.

k. How to determine the time peak demands are made on water system.

l. Procedure for hooking up vehicle cooler system.

m. The testing procedure to be employed.

n. Possible safety hazards (e.g., CO, explosive failure of parts like flywheel and tires, vehicle rolling off dynamometer).

o. Maintenance procedures.

2. Knowledge required to plan the installation of the engine dynamometer including:

   a. Knowledge of best location for device to minimize engine noise to other areas, out of normal shop traffic flow, and with facility provided for moving engine.

   b. Knowledge of necessary service facilities characteristics:

      1) Cooling and load water supply can be either domestic or industrial, temperature not in excess of 80°F, line pressure between 30 and 80 PSI, ideal pH is 9, flow of 4.5 gallons per horsepower per hour.

      2) Cooling and load water disposal must have a minimum of back pressure not to exceed one PSI.

      3) Water must not be excessively hard.

   c. Knowledge of local water characteristics.

   d. Knowledge of local plumbing and electrical codes.

   e. Knowledge of procedures for foundation construction.

   f. Knowledge of floor thickness (top floor mount).

   g. Knowledge of the stability of earth over which dynamometer is to be installed.

   h. Knowledge of procedure for leveling dynamometer.

   i. Knowledge of procedure for installing dynamometer cabinet.

   j. Knowledge of which valve is "load-on" and which is "load-off"

   k. Knowledge that there must be no contact between moving (i.e., power absorption unit) and stationary components.

l. Knowledge of procedure for plumbing and wiring hook-up.

m. Knowledge of whether series or parallel water flow is to be used.

n. Testing procedures to be employed.

o. Possible safety hazards (e.g., CO rotating shafts, hot manifolds, etc.).

p. Maintenance procedures.

References

1. Clayton Manufacturing Co. Instruction manual. Installation, operation, and maintenance. Clayton chassis dynamometer, Model DF-150 and DF-200. El Monte, California: Author.

2. Clayton Manufacturing Co. Instruction manual. Installation, operation, and maintenance. Clayton engine dynamometer, Model 17-300-CE, Model 17-500-CE, and Model 17-700-CE. El Monte, California: Author.

Special Staffing Guidance

The person assigned this task must have a detailed knowledge of the types of testing likely to be performed using the dynamometer (e.g., the sizes of engines or vehicle to be tested, the pollutants to be measured, the need for accessory equipment like water or oil coolers) and other uses of the shop or laboratory facility with which the operation of the dynamometer might interfere. He must be able to coordinate and satisfy various and conflicting design parameters and produce detailed plans for use by plumber, electricians, other construction personnel, and Equipment Technicians. These requirements suggest the need for a Bachelor's Degree in Mechanical or Civil Engineering, a background in engineering drawing, and experience in structural design.

Operation and Maintenance of the Engine Dynamometer

Task Overview

The engine dynamometer is used for measuring power output of a prime mover in a controlled test situation prior to being placed in service. During the test various "experiments" can be conducted to measure and improve engine efficiency, thereby reducing exhaust emissions. The power output shaft of the engine is coupled to the dynamometer shaft, and operation of the engine spins the shaft and rotor which is enclosed in a housing. A tachometer generator, belt driven from the shaft, generates electrical current which is used to actuate the tachometer which indicates engine speed in RPMs. The power output of the engine is absorbed by load fluid within the power absorption unit. The quantity of fluid within the unit is increased or decreased by manipulation of load and unload controls. Within the power absorption unit the rotor, equipped with vanes, turns at close proximity to the stator in a housing partly filled with "load water" and in so doing, develops a rotating vortex of water. This vortex of water transmits kinetic energy to the stator which is attached to the housing. This produces a rotative force on the stator which is equal to the torque output of the engine. The torque forces the entire power absorption unit to rotate on its axis and operate the torque bridge through a system of linkage. As the torque bridge is actuated by the rotating movement of the power absorption unit mounted on cradle bearings, part of the current output of the tachometer generator passes through the torque bridge and actuates the power meter, which indicates engine power output in terms of horsepower. The load water is cooled by being circulated across water-cooled tubes of a heat exchanger by the pumping action of the rotor. Briefly, the steps required for operation and maintenance of the engine dynamometer include:

1. Installation of the engine dynamometer.

2. Operation of the engine dynamometer.

3. Periodic maintenance of the dynamometer.

4. Troubleshooting of the device.

5. Power absorption unit repair.

6. Mechanical balance of the power absorption unit.

7. Hydraulic balance of power absorption unit.

8. Checking relief valve.

9. Servicing torque bridge.

10. Calibration of the dynamometer.

Occupational Category: Equipment Technician

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of an engine dynamometer (the Clayton Engine Dynamometer, Models 17-300-CE, 17-500-CE, and 17-700-CE). The following skill and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to install the engine dynamometer including:

    a. Timing water flow to fill container of known capacity.

    b. Running plumbing lines to carry water.

    c. Drilling anchor holes without breaking through floor.

    d. Correctly filling anchor bolt holes with grout (such as "Embeco") after bolts are placed.

    e. Using hoist and sling to position the dynamometer.

    f. Aligning flexible tubing with frame by determining if power absorption unit rotates when cooling water is turned on.

    f. Using electric drill to make screw holes in cabinet.

    g. Adjusting tachometer generator drive belt.

2. Ability to operate the engine dynamometer including:

   a. Operating load control valves to achieve load desired, coordinating operation with engine throttle adjustments.

   b. Securing engine to be tested so that drive shafts are in line.

   c. Using appropriate flexible drive shaft coupler to attach shafts.

   d. Aligning drive shafts using steel rule and square.

3. Ability to service the engine dynamomerer including:

   a. Cleaning cooling water strainer.

   b. Checking and adjusting flywheel belt tension.

   c. Oiling torque linkage pins, vee blocks, universal joints, and cabinet door hinges and lock.

   d. Lubricating main bearing with grease gun.

   e. Checking and topping-off torque bridge fluid.

   f. Blowing all water from dynamometer and vehicle cooler systems using compressed air.

4. Ability to maintain the chassis and engine dynamometer including:

   a. Removing roughness from shafts and other parts using emery and crocus cloth without damage to the part.

   b. Cleaning scale from heat exchanger by pumping acid solution through it.

   c. Pulling and pressing bearings and housings off and on shafts.

   d. Checking clearances.

   e. Aligning couplings.

   f. Cleaning parts.

   g. Adjusting belt tensions.

   h. Using portable hoist.

   i. Riveting linings to brake shoes (chassis dynamometer).

j. Assembling and disassembling components without damage or loss of parts or injury to personnel.

k. Installing gaskets, "O" rings, and seals without damaging them and using sealers as required.

l. Using a torque wrench.

m. Packing bearings.

5. Ability to troubleshoot the engine dynamometer including:

   a. Determining if valve does not fully close.

   b. Checking and adjusting tachometer generator belt.

   c. Detecting excessive noise and vibration during dynamometer operation.

6. Ability to calibrate the engine dynamometer including:

   a. Using Syncrotac.

   b. Installing calibration beam on power absorption unit.

   c. Correctly positioning weight bracket on calibrating arm.

7. 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.

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

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 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 interpret engineering drawings and piping diagrams.

16. 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 operation of a dynamometer including:

    a. Speed and power meter "Hi" and "Lo" ranges.

    b. Minimum-maximum pressure requirements.

    c. Maximum water temperature limit (195°F).

    d. Shaft rotation direction to be able to adjust tachometer polarity appropriately.

    e. Knowledge not to operate dynamometer completely unloaded or over 150 HP with dynamometer flow control valves closed.

    f. Procedure for installing engine to be tested.

    g. Appropriate shaft couplings, avoiding large and very heavy type industrial couplings.

    h. Procedures for hooking up and turning on engine cooling water (also procedure for turning on dynamometer cooling water).

i. Procedures for starting and operating engine.

j. Procedure for proper engine run-in if engine is new or rebuilt.

2. Knowledge required for servicing the engine dynamometer including:

   a. Maintenance schedule.

   b. Typical properties of torque bridge fluid to assure use of correct fluid.

   c. Procedure for performing periodic checks and lubrication.

   d. Procedure for complete draining of water from system.

   e. Procedure for cleaning water strainer.

   f. Knowledge of procedure for cleaning heat exchanger.

   g. Knowledge of procedure for replacing packing rings.

3. Knowledge required for maintaining the engine dynamometer including:

   a. Procedures for disassembly, inspecting, adjusting assembly and testing of various components of the dynamometer.

   b. The correct cleaning solutions, concentrations, and methods to be used in cleaning the various components.

   c. Safe handling procedures for hydrochloric acid and paraformaldehyde (e.g., wearing rubber gloves, etc.).

   d. Identification of all parts as they are removed from power absorption unit to be sure they are replaced in the same place.

   e. The use of new seals and running rings when assembling absorption unit.

   f. Use of machinist's level.

4. Knowledge required to calibrate the engine dynamometer including:

   a. Proper place to install Syncrotac.

    b. Procedure for speed meter calibration.

    c. Procedure for power meter calibration.

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.

<u>References</u>

1. Clayton Manufacturing Co. <u>Instruction manual. Installation, operation, and maintenance. Clayton engine dynamometer, Model 17-300-CE, Model 17-500-CE, and Model 17-700-CE</u>. El Monte, California: Author.

<u>Special Staffing Guidance</u>

1. Because of the high skill and knowledge requirements for this task it should be assigned to a senior level Equipment Technician.

2. The skills and knowledge required for this task are similar to those required for operation and maintenance of the chassis dynamometer so the same Technician should be assigned to both tasks (where the agency has both types of dynamometer).

Operation and Maintenance of the Chassis Dynamometer

Task Overview

The chassis dynamometer is used to measure both the power and speed of vehicles. As the vehicle is operated on the dynamometer, its drive wheels are cradled between two rollers. A load is applied to the forward or "drive" roller. The load may be increased, decreased, or held constant at the option of the operator. These different loads are used to check vehicle performance while accelerating, decelerating, and operating with maximum load. The drive wheels of the vehicle rotate two ball bearing mounted rollers. The drive roller is coupled to the power absorption unit, and to an inertia flywheel. The rear or "idle" roller is used to drive a tachometer generator. The power absorption unit is composed of a shaft, rotor, stator, and heat exchanger, enclosed within a housing. The drive roller turns the rotor at the same speed as the roller, and in the same direction. The rotor, equipped with vanes, turns at close proximity to the stator in a housing partly filled with "load water" and in so doing, develops a rotating vortex of water which transmits kinetic energy to the stator which is attached to the housing. This produces a rotative force on the stator which is equal to the torque output of the vehicle, and a torque arm delivers this force to the load cell which, in turn, sends a signal to the power meter. Load water enters or leaves the load water circuit as the load or unload valve is opened. As the volume of water within the power absorption unit is increased, more power is absorbed. Conversely, decreasing the volume of water decreases the load. The load water is cooled by being circulated across water-cooled tubes of a heat exchanger by the pumping action of the rotor. Briefly, the steps required for operation and maintenance of the chassis dynamometer include:

1. Installation of the dynamometer.
2. Placing the vehicle on the dynamometer.
3. Operation of the vehicle on the dynamometer.

4. Periodic maintenance of the dynamometer.
5. Troubleshooting of the device.
6. Vehicle cooler pump and motor service.
7. Vehicle cooler heat exchanger cleaning.
8. Roller bearing replacement.
9. Solenoid load-unload valve cleaning.
10. Servicing remote load control.
11. Power absorption unit replacement.
12. Load cell service.
13. Tachometer generator service.
14. Inertia flywheel unit service.
15. Speed meter calibration.
16. Power meter calibration.

Occupational Category: Equipment Technician

Task Description

Reference 1 provides an example of the procedures for operation and maintenance of a chassis dynamometer (the Clayton Chassis Dynamometer, Models DF-50 and DF-200). The following skill and knowledge requirements are representative of this category of tasks.

Skill Requirements

1. Ability to install the chassis dynamometer including:
    a. Running plumbing lines to carry water.
    b. Reading engineering drawings and blueprints.
    c. Drilling anchor holes without breaking through floor (top floor mount).
    d. Correctly filling footing and anchor post hole with grout (such as "Embeco") after chassis is installed (top floor mount).

e. Removing paint from trunnion.

f. Installing roll lock disc using light hammer and electric drill.

g. Operating portable hoist.

h. Squaring anchor post with frame.

i. Drilling 1/2 inch holes in 4-inch by 4-inch timbers to match holes in dynamometer frame. The timbers are laid across each end of dynamometer and extend at least 12 inches beyond edge of foundation.

j. Centering dynamometer by aligning center punch-out on frame with center line of floor after dynamometer is raised to level with floor using bolts passed through the frame and timbers.

k. Blocking dynamometer to achieve stability by placing one-inch boards cut to length between frame and foundation at all four corners.

l. Determining when grout has reached a strength of 1,500 PSI.

m. Timing water flow to fill container of known capacity.

n. Adjusting tachometer generator belt tension.

o. Bleeding air from load cell.

p. Injecting transmission fluid into line connecting power meter and load cell and bleeding air from system.

q. Priming cooler pump motor.

r. Securing ramps to floor with bolts (top floor mount).

2. Ability to operate the chassis dynamometer including:

   a. Aligning vehicle on dynamometer. This is aided by painting a stripe on floor along driver's side.

   b. Judging power absorption unit temperature by feeling with palm of hand.

c. Controling load with load control pushbuttons.

d. Coordinating vehicle throttle and load control adjustments to maintain preselected speed and opening throttle fully.

e. Blowing all water from dynamometer and vehicle cooler systems using compressed air.

3. Ability to service the chassis dynamometer including:

   a. Replacing magnesium plug-in power absorption unit.

   b. Lubricating flywheel bearings and pins and guide channels actuated by flywheel engagement lever.

   c. Cleaning cooling water strainer.

   d. Checking and adjusting tachometer generator belt tension.

   e. Checking and adjusting flywheel belt tension.

   f. Checking and adjusting flywheel brake adjustment.

   g. Lubricating flexible shaft couplings by installing lubrication fitting and injecting lubricant.

   h. Removing grease, oil, and water from rollers and approach to dynamometer.

4. Ability to troubleshoot the chassis dynamometer including:

   a. Locating bend or deflect in hoses.

   b. Checking drive belt tension.

   c. Checking electrical power supply.

   d. Checking if pump is primed.

   e. Detecting excessive noise and vibration during dynamometer operation.

5. Ability to maintain the chassis and engine dynamometer including:

   a. Removing roughness from shafts and other parts using emery and crocus cloth without damage to the part.

   b. Cleaning scale from heat exchanger by pumping acid solution through it.

c. Pulling and pressing bearings and housings off and on shafts.

d. Checking clearances.

e. Aligning couplings.

f. Cleaning parts.

g. Adjusting belt tensions.

h. Using portable hoist.

i. Riveting linings to brake shoes (chassis dynamometer).

j. Assembling and disassembling components without damage or loss of parts or injury to personnel.

k. Installing gaskets, "O" rings, and seals without damaging them and using sealers as required.

l. Using a torque wrench.

m. Packing bearings.

6. Ability to calibrate the chassis dynamometer including:

a. Installing calibration arm on torque arm.

b. Correctly positioning weight stand on calibrating arm.

c. Moving load cell in or out to achieve proper readings.

d. Resetting tare on power meter by removing face and turning micrometer screw on meter hand.

7. 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.

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

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

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 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 installing a dynamometer.

2. Knowledge of the operation of the dynamometer including:

    a. Procedure for locking dynamometer rollers.

    b. Maximum allowable temperature of power absorption unit (150°F).

    c. Knowledge that flywheel must not be engaged while rollers are turning, or disengaged while operating in excess of 20 MPH.

    d. Safe top speed when flywheel is operating (65 MPH).

    e. Procedure for attaching vehicle cooler to vehicle (water cooled).

    f. Procedure for completely draining dynamometer and cooler of water.

3. Knowledge required for servicing the dynamometer including:

    a. Preventive maintenance schedule.

    b. Procedure for performing periodic checks and lubrications.

4. Knowledge required for troubleshooting the dynamometer including:

    a. Symptom patterns.

    b. Techniques for using symptom/cause table.

5. Knowledge required to maintain the dynamometer including:

    a. Procedures for disassembly, inspection, and assembly of various components of the dynamometer.

    b. Proper cleaning solution concentration to be used in various stages of cleaning.

    c. Safe handling procedures for hydrochloric acid and paraformaldehyde (e.g., wearing rubber gloves, etc.).

    d. Procedure for checking alignment of shaft coupling hubs.

    e. Procedure for attaching and operating a bearing puller.

    f. Technique for identifying hoses to assure connection to correct fittings upon replacement.

6. Knowledge required to calibrate the dynamometer including:

    a. Knowledge that there is no tire slippage, tachometer belt slippage, loose or broken wires or tubing before beginning calibration.

    b. Procedure for use of the Syncrotac.

    c. Characteristics of smooth-running vehicle.

    d. Procedure for calibration of speed meter.

    e. Procedure for calibration of power meter.

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 tools and materials required for maintaining the instrument.

References

1. Clayton Manufacturing Co. Instruction manual. Installation, operation, and maintenance. Clayton chassis dynamometer, Model DF-150 and DF-200. El Monte, California: Author.

Special Staffing Guidance

1. Because of the high skill and knowledge requirements for this task it should be assigned to a senior level Equipment Technician.
2. The skills and knowledge required for this task are similar to those required for operation and maintenance of the engine dynamometer so the same Technician should be assigned to both tasks (where the agency has both types of dynamometer).