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DEVELOPMENT OF WRITTEN TESTS FOR CERTIFICATION OF EMISSION LABORATORY TECHNICIANS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

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Prepared by

Harold J. Wimette, D. Gene Davis, and John Gunderson

Olson Laboratories, Inc.
421 East Cerritos Avenue
Anaheim, California 92805

Contract No. 68-01-2109

EPA Project Officer:

William H. Houtman

Prepared for

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FOREWORD

This is the final report on the development of the written and practical test for emission laboratory technicians conducted at Olson Laboratories, Inc. for the Environmental Protection Agency under Contract No. 68-01-2109.

The work was administered under the direction of the Emission Characterization and Control Development Branch, Office of Mobile Source Air Pollution Control, Office of Air and Waste Management, at Ann Arbor, Michigan. The EPA project officer for the program was Mr. William H. Houtman.

During the initial phase, Mr. Milton Webb was the project engineer assigned to this program. Mr. Harold J. Wimette replaced Mr. Webb in August of 1973 as project engineer and served in this capacity for the remainder of the program. Program management for both the initial and final phases was the responsibility of Mr. John Gunderson.

The significant technical contributions to this effort by Mr. Houtman, of the Environmental Protection Agency. Dr. D. G. Davis, of UCLA, and the members of the seminar panel are acknowledged.

ABSTRACT

This final report was prepared by Olson Laboratories, Inc., an Envirodyne Company, for the Environmental Protection Agency, Office of Air and Water Programs, under Contract 68-01-2109. Work was conducted during the period of June 1973 through May 1974. The objective of the work described in this report was to develop a written and practical test for emission laboratory technicians as part of the EPA program for developing regulations for the certification of emission laboratories which conduct the EPA regulatory test.

The basis for developing the test items were the Federal Registers subparts A, B, C, H, I and J covering both light duty vehicle and heavy duty engine emission measurement requirements and procedures.

Test development guidelines used for the preparation of vocational technical training and other job related tests were utilized to develop the written test.

A technical review panel was selected from representatives of automobile manufacturers and independent laboratories. Three seminars were held during which the panel members assisted in preparation of a task analysis, the writing

of the test items and item analysis. The test was administered to technicians and engineers at the Ann Arbor facility.

A practical test consisting of both a manipulative and oral test was also developed by preparation of an examiner task analysis, testing guidelines and procedures, and a practical test item form.

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SECTION 1

INTRODUCTION

The Environmental Protection Agency is currently engaged in developing regulations for the certification of emission laboratories which conduct EPA regulatory related tests.

One element of this emission laboratory certification program requires the examination of laboratory technicians to assure they have attained the necessary level of competence in performing required laboratory functions. The examination is comprised of a written test of operational knowledge and a practical test to evaluate the performance of the technician "on the job."

The basis for developing the test items were the Federal Registers Subparts A, B, C, H, I and J. These cover the light duty vehicle and heavy duty engine emission measurement requirements and procedures. Particular attention was given to those paragraphs involving the test technician rather than the manufacturer or a certification engineer.

1.1 WRITTEN TEST FOR THE CERTIFICATION OF EMISSION LABORATORY TECHNICIANS

Test development guidelines used for the preparation of vocational technical training and other job related tests were utilized to develop the written test. Olson Laboratories was assisted in the test development by a technical review panel consisting of experts in the field of emission measurement from industry, independent laboratories and the EPA. The panel participated in the three seminar workshops conducted by Olson Laboratories. A consultant, knowledgeable in the field of task analysis procedures and test development, assisted the Olson team in planning and conducting the workshops.

The panel members assisted in the development of a task analysis, writing the questions (test items) and analysis and documentation of the test items. The test was demonstrated by administering it to approximately 40 technicians and engineers at the EPA test facility in Ann Arbor, Michigan.

The program methodology is discussed in Section Two. Further details of the written development and workshop seminars are discussed in Section Three, Four and Five.

1.2 PRACTICAL EXAMINATION FOR THE CERTIFICATION OF EMISSION LABORATORY TECHNICIANS

In addition to the written test, Olson Laboratories has developed a practical test for emission technicians. It consists of both a manipulative and oral test similar in nature to the practical test used by the Federal Aviation Administration for certification of aircraft mechanics.

Much of the material and information obtained in developing the written test were also used in the development of the practical test as discussed in Section Six of this report.

Both the written and practical tests have been previously delivered to the EPA and for test security reasons are not included as part of the final report.

SECTION II

TEST DEVELOPMENT METHODOLOGY

In the Development of the written examination for the certification of emission laboratory technicians Olson Laboratories has chosen an established method in the vocational-technical training field. The Equal Employment Opportunity Coordinating Council has recently recommended similar guidelines for preparation of job related tests.[1,2,3] These guidelines were adopted from those developed by the American Psychological Association.[4]

Briefly the Recommended Procedure for test development involve the following tasks:

- Preparation of a job description
- Task Analysis (Job Analysis)
- Item (Question) Development
- Test Demonstration
- Item Analysis

Similar guidelines were used in the preparation of the practical test. Development of the practical test is discussed in Section Six. To support Olson Laboratories in developing the examination, a Technical Review Panel, experienced in emission laboratory testing, was organized

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[1] Page 4413 (References are listed in Section 7)

[2] Paragraph 60-3.6, pages 2095-2097

under the direction of the EPA Project Officer. Three workshop seminars were held during which the panel members participated in the: (1) development of the task analysis (2) test item development and (3) item analysis. A program overview showing the interrelationship of the program tasks appears in Figure 2-1.

2.1 SELECTION OF THE REVIEW PANEL

The selection of the Technical Review Panel was extremely important to insure the validity of the development of the written test. The selection of the panel involved the consideration of: (1) the technical background of the individual panel members; (2) the industry sources from which to draw panel members, and (3) the number of members.

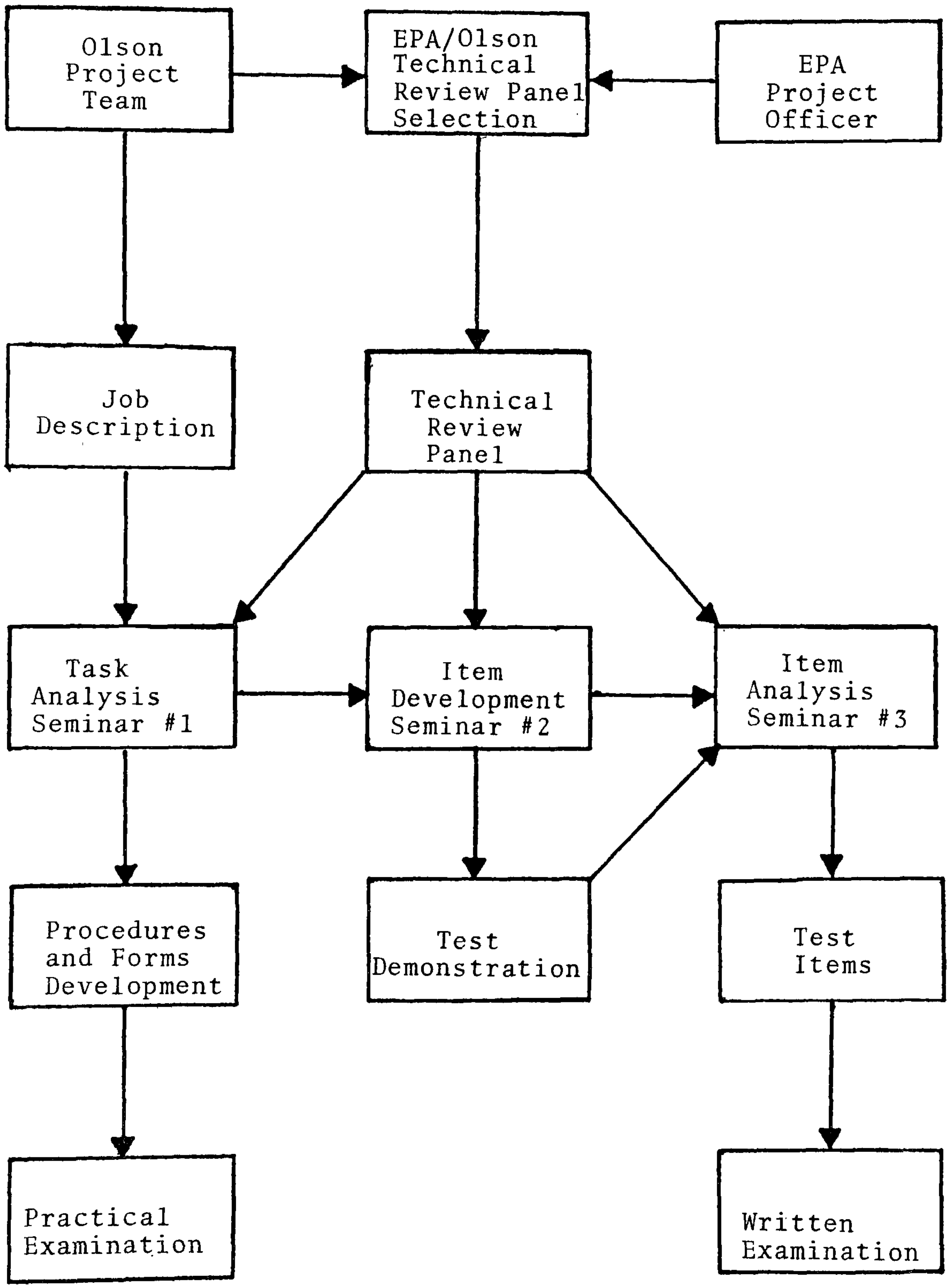
2.1.1 Technical Background

The examination covers several technical areas of emission testing which are listed as follows:

1. Exhaust emission measurement of gasoline-fueled light duty vehicles (FR85 Subpart A).
2. Exhaust emission measurement of diesel-fueled light duty vehicles (FR-5 Subpart B).
3. Exhaust emission measurement of gasoline-fueled light duty trucks (FR85 Subpart C).

Figure 2-1

PROGRAM OVERVIEW



4. Exhaust emission measurement of gasoline-fueled heavy duty engines (FR85 Subpart H).
5. Smoke emission measurement of diesel-fueled heavy duty engines (FR85 Subpart I).
6. Measurement of gaseous exhaust emissions from diesel-fueled heavy duty engines (FR85 Subpart J).

For complete listing of the Federal Registers involved see Section 3.1.

Since the examination was to cover such a diverse field of emission measurement it was necessary that the panel reflect this same diverse experience.

Initially a letter was sent out to companies and organizations involved in emission testing, asking for their participation in this program. They were asked to submit a resume of their candidate if they wished to participate in the program.

The resumes submitted were evaluated and the panel selected on the basis of their experience in the emission field under the direction of the EPA Project Officer. Selection was made from both the professional and technical field and was representative of all the specified areas of emission measurement.

The measurement technique used for light duty vehicles and heavy duty engine emissions are dissimilar in many respects. Therefore, it was decided to divide the members into two Panels consisting of nine members each. A brief resume of the panel members appears in Table 2-1 for the light duty vehicle panel and Table 2-2 for the heavy duty engine panel.

2.1.2 Source

For light duty vehicles, panel members were selected from automotive manufacturers both domestic and foreign, independent test laboratories and the EPA.

For heavy duty vehicle engines, panel members were selected from manufacturers of heavy duty gasoline and diesel engines, independent test laboratories and the EPA.

2.1.3 Panel Size

Olson's past experience in development of examinations, indicated that a Panel consisting of approximately ten members is best for efficient workshop operations. It was also evident that dividing the group into smaller teams with specific assignments was more productive. However, all the members of the Panel were allowed to review and comment on the work of other teams.

TABLE 2-1

BRIEF RESUME OF THE LIGHT DUTY VEHICLE PANEL MEMBERS

PANELIST	POSITION	ORGANIZATION	SUBPART ASSIGNMENT	BACKGROUND
R. Wiquist	Sr. Project Engineer	Chrysler	A	Data analysis, correlation operations and correlation of emission test equipment.
R. Lord	Research Engineer	Ford	B	Analytical instrument operation, driver, instr. evaluation, calibration.
R. Prevost	Asst. Staff Engr.	GM	B	Supervision, emission testing.
C. Senko	Sr. Test Tech.	AMC	C	Preparation of vehicles for cert. testing, witness testing for ARB & EPA.
J. Parcells	Ems. Lab. Supervisor	Toyota	B	Survey of new and used car emissions, instrumentation development, supervise exhaust emission testing.
J. Baronick	Supervisor (Germany)	VW	A	Supervision of exhaust emission measurement, correlation between labs, new instrumentation evaluation.
J. Shelton	Engineering Tech.	EPA	C	Light Duty vehicle emission testing and emission lab correlation.
J. Lorance	Supr. Tech. Service	AESI	C	Design development & operation of emission system. Project engineer on emission test programs.
W. Becktal	Project Leader	ATL	A	All phases of certification testing, driving, data red., instruments, test procedures.

TABLE 2-2

BRIEF RESUME OF THE HEAVY DUTY ENGINE PANEL MEMBERS

PANELIST	POSITION	ORGANIZATION	SUBPART ASSIGNMENT	BACKGROUND
J. Harrod	Foreman	Cummins	J	Diesel exhaust emission measurements, supervises test tech.
L. Bausback	Lead Technician	Cummins	I	Diesel smoke emissions.
J. Ortlieb	Research Engr. Dept.	Cummins	I	Responsible for technician training programs, Union guideline experience.
R. McDowell	Project Engr.	Caterpillar	I	Supervision of certification tests for HD diesel exhaust and smoke emissions.
D. Nelius	Sr. Experimental Engineer	Detroit Diesel	J	Maintenance, calibration, operating and research application of emission equipment.
R. Oldsen	Supervisor	International Harvester	H	Supervision of gasoline engine labs, certification tests, dyno maintenance, calibration procedures.
R. Clark	Ems. Laboratory Supervisor	EPA	J	Design and construction of emission analyzer systems, heavy duty engine certification & both heavy and light duty emissions measurement experience.
J. Sundahl	Project Engr.	AESI	H	Heavy-duty testing (6-10K) using LD test cycle, CVS system & other system calibration.
M. Ingalls	Sr. Res. Engr.	SW	H	HD gasoline test procedures, surveillance, on-the-road exhaust emisssion, gasoline & diesel.

Nine members were selected for each panel. Each panel was then divided into three groups. These groups were each assigned a subpart of the Federal Register on which they would concentrate.

2.2 CONSULTANT PARTICIPATION

An examination development specialist assisted the Olson team in the development of the written certification examination. The Consultant, Dr. D. Gene Davis, actively participated in the planning and preparation of material for the three seminars. In addition he assisted in conducting the workshop seminars and the examination demonstration.

Dr. Davis, teacher educator for graduate programs in the School of Education at the University of California, Los Angeles, has extensive experience in education and consulting with industry in the area of test development and implementing test demonstration programs.

2.3 CLASSIFICATION OF TECHNICIANS

The first step in the development of a test is to write a job description for the person being tested. A job description is a general statement about what a person on the job does, and describes the conditions under which he does them.

Writing a job description for test technicians proved to be a difficult job because of the great differences in personnel and equipment utilized by the various organizations in the emission field. However, it was necessary to develop job descriptions for two reasons: (1) In order that the written test could be subdivided into general technician classifications, and (2) As a starting point for the development of the task analysis.

2.3.1 Classification

It is reasonable to assume that the emission tests are conducted by more than one person possessing varying degrees of skill level and job requirements.

This would necessitate the subdivision of the examination in order that the technician could be certified for the particular job.

There is, however, considerable overlap in the responsibilities of these technicians which varies from one company to another. It was decided that rather than examine a particular person doing the job the examination would be divided into the following identified classifications.

Light Duty Vehicle Emissions

1. Vehicle Preparation and Evaporative Emissions.
2. Test Driver.
3. Data Reduction.
4. Instrument Operator.

Heavy Duty Engine Emissions

1. Data Reduction.
2. Instrument Operator.
3. Dynamometer Operator.

It is possible that a technician could be qualified in more than one classification and in some cases in all classifications. Therefore, a person who might be responsible for the certification of emission tests may be required to be proficient in all phases of the testing operation and would be required to pass all sections of the examination for either or both light duty and heavy duty. This person could be classified as a master test technician.

2.3.2 Job Descriptions for Task Analysis

The Olson team under direction of the EPA Project Officer prepared the following list of job descriptions to be used by the panelist as a starting point for the task analysis.

Emission Test Personnel Duties

1) Vehicle Preparation: Prepares vehicle for exhaust and evaporative emission test. Checks tire pressures, adapts fuel system for consumption measurements, and prepares evaporative emission test canisters. Does not include vehicle tune-up.
2) Vehicle Test Driver: Drives vehicle through test cycle. Sets dynamometer load and inertia weights for tests. Connects sampling system for tests.
3) Data Reduction Analysts: Reduces measured data and calculates final test results either manually with calculators or by programming and computer methods.
4) Analytical Instrumentation Technician: Operation of emission sampling system, instrument system for measuring pollutant concentrations, calibrations of instruments, and equipment maintenance.

5) Master Test Technician: Conducts and/or directly supervises all emission test operations. Must have experience as a test driver, data reduction analyst, and an analytical instrument technician.

6) Emission Engineer, Gasoline Engines: Supervision and understanding of all emission test operations, and have responsibility in determining the validity of official test results for gasoline-fueled vehicles or engines.

7) Emission Engineer, Diesel Engines: Supervision and understanding of all emission test operations, and have responsibility in determining the validity of official test results for diesel-fueled vehicles or engines.

8) Engine Dynamometer Operator: Set-up of engine for heavy duty emission tests and operation of engine dynamometer during official emission tests.

This list was submitted to the technical review panel during Seminar I. Classifications 1, 2, 3, 4 and 8 were used by the panelist in the task analysis. Classifications 5, 6 and 7 were general descriptions of jobs which would require knowledge and skill of all classifications within a major classification (i.e. - Either light duty vehicle or heavy duty engine.). This list was used only as a starting point for the task analysis procedure and is not related to any classification plans of EPA.

2.4 WORKSHOP SEMINARS

The technical review panel participated in three workshop seminars. Each seminar was three days in length and held October 23-25, December 11-13, 1973 and February 18-21, 1974. Because the skills in test development learned in the first seminar would be used during the other two seminars, only panel members attending the first meeting were allowed to participate in the remainder of the program: This procedure was necessary so that a participating company would not send an alternate candidate to each of the three meetings. This would require reviewing the previous work and training in test development with every new panel member. There were other considerations also for keeping the same membership throughout the program among which were to avoid the introduction of problems or disagreements which had been worked out in previous meetings, and the familiarity of the members meant a better team effort could be achieved. Attendance was good with only three members not being able to attend all three seminars.

Panel members received instructional material approximately one week in advance. They were asked to review the material in advance in preparation for the seminar.

Each seminar began with a discussion of the objectives and the methods used to develop test items and an overview of the seminar with a brief review of the previous seminar.

During Seminar I the Olson team explained the methods in determining job classification, job descriptions, and task analysis procedures. Dr. Davis further explained the background and purpose of the task analysis. Questions were answered and individual assistance was given to the panel members throughout the seminar. A review was held each morning prior to the start of the work sessions. The participants were asked to finalize the classification of emission test technicians (Job Description). They were then asked to review and complete the task analysis previously prepared by Olson Laboratories. The development of the task analysis is discussed in Section 3.

Seminar II was used to write the test items using the specifications and task analysis of Seminar I. Section 4 details procedures used for the construction of test items.

The panel members were given the examination at the start of Seminar II. Item analysis of individual test questions was performed by the Olson team. The panel members were asked to rewrite those test items that were not clear or incorrect or not directly job related. The procedure used for item analysis on the written test is described in Section 5.

Since technicians from emission testing laboratories may be required to take the test it was determined that security policies be established. The EPA requested that panel members not discuss the development of the test items at any time outside the seminars.

Notes and drafts prepared by Olson Laboratories and the technical review panel were collected and secured at the end of each seminar day and following each seminar session.

2.5 TEST DEMONSTRATION

After the development of the test items by the panelists during Seminar II the examination was given to approximately 40 EPA technicians and engineers. In a few cases the technician was allowed to take both the light duty vehicle and the heavy duty engine examination if they had experience in both areas. As a result there were 30 light duty tests and 13 heavy duty tests taken. At the beginning of Seminar III the light duty examnination was taken by nine panelists and the heavy duty by eight panelists.

The people taking the exam had a wide range of experience and educational background. Therefore, it was necessary to determine something about their technical background in order to correctly interpret their answers in the test item analysis procedure. Figure 2-2 is a sample of the form given to the test examinee. Exams were identified by number only. No surnames were used for the exam given to the panel members.

Instructions were given to answer the questions according to the latest Federal requirements. In addition they were asked to make comments on the examination booklet about any of the items that they thought might be misleading or incorrect. These comments were then used as part of the test item analysis. In addition, after completion of the exam participants were asked to fill out an evaluation form (Figure 2-3).

TECHNICAL BACKGROUND

Test Number__________

Education: (List all schools attended)

High School____________________ Diploma: Yes______ No______________

College________________________ Years_____________ Degree_____________

________________________ Years_____________ Degree_____________

Job related courses and special training programs___________________

____

____

Experience:

Present Job Title____

Length of time in this job_____ Years_____________ Months_____________

Previous jobs related to the emission field or some special skill you are presently using such as Mechanic, Engineering Aid, Data Audit or Lab. Technician:____

____

____

Experience in emission testing: Months_______________________________

1. Test vehicle preparation ____________________________________
2. Evaporative Emissions ______________________________________
3. Test vehicle driver ____
4. System operator ____
5. Engine Dyno installation_______________ Operation_______________
6. Smoke measurement ____
7. Data reduction ____
8. Total emission experience________ Light Duty______ Heavy Duty______

Other Related Experience:____

____

____

____

____

Figure 2-2

Examination No.__________

EVALUATION OF EXAMINATION

To improve the exam in the final form we would appreciate your assistance in completing the following questions.

1. Do you feel this examination covers the emission technicians job responsibility: Closely_____ Moderately_____ Little_____ Not at all__________

2. Do you feel the exam was well organized? Yes_____ No_________

3. What was your impression of the degree of difficulty of the exam? Too elementary______ Too Advanced____ About Right_____

4. Were the questions in general:

   Understood__________________ Not Understood__________________

5. Could you finish the test in the time allowed? Yes___ No_____

   Which sections were not completed?

   Light Duty: 1-1 1-2 1-3 1-4

   Heavy Duty: 2-3 2-4 2-8

6. Did you try to answer all the questions even if you were not sure of the correct answer? Yes___________ No______________

7. Did you leave the question unanswered if you did not understand the question? Yes_________________ No_______________

8. Additional Comments:____

   ____

   ____

   ____

   ____

Figure 2-3

SECTION III

TASK ANALYSIS

The first seminar involved the review and completion of the Job Classification and task analysis previously initiated and developed by Olson Laboratories. Task analysis is an essential procedure in test item development. By listing and analyzing each detailed task performed by the technician the important areas can be determined and those of lesser importance can be avoided or de-emphasized in preparing test items.

3.1 TASK LIST

The first step in the task analysis procedure is the preparation of a list detailing as much as possible the steps performed by the test technician.

The sources used for the Task List were as follows:

- Federal Register, Volume 37, No. 221, November 15, 1972
- Federal Register, Volume 38, No. 124, June 28, 1973
- Federal Register, Volume 38, No. 151, August 7, 1973
- SAE J177 Measurement of Carbon Dioxide, Carbon Monoxide, and Oxides of Nitrogen in Diesel Exhaust.
- SAE J244 Measurement of Intake Air on Exhaust Gas Flow of Diesel Engines.
- SAE J215 Continuous Hydrocarbon Analysis of Diesel Emissions.
- SAE J255 Diesel Engine Smoke Measurement (Steady State)

The panel members were asked to supplement these sources with their own company procedures, if available, and their own experience and training in the emission field. It was stressed that there are many things not in the Federal Register that are required for performing an emission test. Knowledge of these tasks are important in the development of the test items and should be included in the task list.

The item list covered five general categories: terminology; test procedures; analytical system; data reduction and durability testing. This was further broken down into nine procedures or task categories.

1. Vehicle or engine preconditioning, evaporative emissions and vehicle test preparation.
2. Testing for emissions.
3. Instrument analyses.
4. Calculations.
5. Maintenance.
6. Troubleshooting.
7. Calibration - instruments and equipment.
8. Theory.
9. Safety.

Each panelist was encouraged to develop the task categories with which they were most familiar. But it was requested that all task categories be completed for each subgroup. In some cases this involved repetition of similar tasks among the subgroups.

3.2 TASK ANALYSIS

The second step of test development is the task analysis. The task analysis involved the analysis of each task item for:

- Frequency of Performance
- Skill level required
- Importance of the task

In addition to instructions given by the Olson team the panelists were given a description of the job analysis technique to be used. This "hand out" is presented in Appendix A and describes in detail the procedures used for task analysis.

The task analysis is presented in Appendix B. This was the original compilation of the task analysis as submitted by the panel. Duplication of submitted task items were eliminated prior to Seminar II. It was used as a working tool to develop the examination questions, therefore, corrections and omissions noted by the panelists in a review of the task analysis were not included in this draft copy.

It can, however, be used as a guide for developing a task or "job analysis" for technicians in a particular laboratory or company.

3.2.1 Frequency of Performance

A rating system of one to five was used by the panelists to indicate the frequency each task was performed. The rating code is as follows:

1. Monthly
2. Biweekly
3. Weekly
4. Daily
5. Every test

3.2.2 Skill Level

Tasks performed by a technician do not require the same skill level. The panelists were asked to give their evaluation of the learning difficulty of each task or the difficulty of acquiring the particular skill. For example, operating an engine dynamometer might require a higher level of skill than installing the engine exhaust system. The following rating was used by the panel for the skill or learning difficulty:

1 = Easy to learn

3 = Moderate skill or learning level

5 = Difficult to learn or high degree of skill

3.2.2 Importance of the Task

Tasks are not of equal importance in the performance of an emission test. Tasks that are performed frequently may not represent a critical skill. Other tasks, although performed rarely, are vital to the performance of a valid emission test. The panelists were asked to use their judgement to rate the importance of each task in terms of performing a valid emission test. The rating scale used is as follows:

1 = Unimportant

2 = Moderately Important

3 = Very important

SECTION IV

TEST ITEM DEVELOPMENT

The task analysis prepared by the technical review panel was consolidated to avoid duplication and reviewed by Olson Laboratories and the EPA.

This working document was then given to the panel members at the second seminar to use in preparing test items.

The panel members were assigned to the same subpart team as the first seminar.

4.1 TEST ITEM CLASSIFICATION

The panelists were asked to develop as many items as they could during the three day seminar. In order to avoid confusion as to which area of emission measurement the question was directed, a numerical classification system was devised. This system could also be used in the future to catalogue the questions and allow an examiner to pick the questions from a "data bank" for a particular examination. The classification used is shown in Table 4-1.

4.2 TEST ITEM DEVELOPMENT PROCEDURES

Olson Laboratories prepared a list of sample questions prior to the seminar for both heavy duty and light duty panels. Those questions were distributed, discussed and evaluated with the panel members.

TABLE 4-1

NUMERICAL CLASSIFICATION OF TEST ITEMS

Major Classification:	1.	Light duty vehicle emissions
	2.	Heavy duty engine emissions
Minor Classification: (Job)	1.	Vehicle preparation
	2.	Vehicle test driver
	3.	Data reduction analyst
	4.	Analytical instrumentation technician
	8.	Engine dyno operator
Categories:	1.	Terminology
	2.	Test procedures
	3.	Analytical systems
	4.	Data reduction
	5.	Durability testing
Procedure (Task Category):	1.	Vehicle or engine preconditioning-evaporative emissions- test preparation
	2.	Testing for emissions
	3.	Instrument analyses
	4.	Calculations
	5.	Maintenance
	6.	Trouble shooting
	7.	Calibration-instruments & equipment
	8.	Theory
	9.	Safety
Federal Register: Subpart	A	Light duty vehicle gasoline fueled
	B	Light duty vehicle diesel fueled
	C	Light duty trucks gasoline fueled
	H	Heavy duty engines gasoline fueled
	I	Heavy duty engines smoke emissions
	J	Heavy duty engines diesel fueled

The panel members were given a "hand out" discussing the preparation of test items. This discussion of the types of items and general rules for construction of test items appears in Appendix c.

4.2.1 Test Item Categories

The written test for the certification of emission laboratory technicians is an objective type test for technicians. Three categories of objective questions were chosen for the construction of the examination, they were:

1. Alternate - Response Item (True-False)
2. Multiple Choice Item
3. Matching Exercises

4.2.1.1 Alternate-Response Item (True-False)

Alternate response items are those in which only two alternatives are presented. The most common are the True-False, requiring an answer concerning the truth or falsity of a statement. An example of this type appears in Figure 4-1 as it would appear in the Item Development Form used by the panelists. Sample questions of this type taken from the "data bank" are presented in Appendix D-1.

ITEM DEVELOPMENT FORM

TEST ITEM CLASS

2	8	2	2	J		

ITEM CATEGORY

/X/ Alternate-Response

/ / Multiple Choice

/ / Matching

MINOR CLASS Dynomometer Operator

APPLIES ALSO TO

ITEM DEVELOPED BY Olson Laboratories

TESTS KNOWLEDGE OF Test Procedures

REMARKS

Before performing the 13 mode emission cycle the engine temperatures and pressures are allowed to stabilize

TRUE X FALSE ____

4.2.1.2 Multiple Choice

Multiple choice items are the most popular form for standardized testing. However, it is the most difficult of the objective type items to construct. The multiple choice item commonly consists of an incomplete statement with varying degrees of accuracy. The answer which is most correct or best completes the statement is to be chosen and typically this choice is indicated by an answer appearing in a column at the left or the right side of the paper. An example is given in Figure 4-2 and sample questions appear in Appendix D-2.

4.2.1.3 Matching Exercises

Matching exercises are in effect combinations of multiple choice items in such a manner that the choices are compounded in number. Matching exercises differ from other objective forms in the fact that they must occur in groups. Matching tests are by nature multiple in type and the number of scoring points is ordinarily determined by the number of responses required. An example of a matching type item appears in Figure 4-3 and sample questions are presented in Appendix D-3.

Figure 4-2

ITEM DEVELOPMENT FORM

TEST ITEM CLASS

1	4	2	3	B		

MINOR CLASS Instrument Technician

APPLIES ALSO TO ____________

ITEM DEVELOPED BY Olson Laboratories

TESTS KNOWLEDGE OF Diesel measurement

REMARKS ____________

ITEM CATEGORY

/ / Alternate-Response

/X/ Multiple Choice

/ / Matching

The hydrocarbon in the exhaust emissions from light duty diesel vehicles are determined by:

(a) Analysis of a bag sample collected during the Hot transient test.

(b) Integration of a continuous HFID trace.

(c) A non-dispersive infrared detector

(d) Gas chromatographic analyses of the bag sample.

(e) None of the above. . . . . (b)

Figure 4-3

ITEM DEVELOPMENT FORM

TEST ITEM CLASS

1	4	1	8	A	B	C

MINOR CLASS Instrument Tech.

APPLIES ALSO TO 2-4-1-8 H, J,

ITEM DEVELOPED BY Olson Laboratories

TESTS KNOWLEDGE OF Chemical make-up of the primary components of the exhaust.

REMARKS

ITEM CATEGORY

- [ ] Alternate-Response
- [ ] Multiple Choice
- [x] Matching

Match the definition with the chemical compound:

e	A heavy, colorless nontoxic, non-combustible gas; a by-product of complete combustion.	a.	Nitric Oxide
d	A colorless, odorless, toxic, combustible gas; a by-product of incomplete combustion.	b.	Nitrogen
a	A colorless, toxic gas formed by the oxidation of nitrogen; also a by product of the combustion of hydrocarbon fuels.	c.	Nitrogen Dioxide
b	A colorless, tasteless, odorless, nontoxic gaseous element that constitutes 78 percent of the atmosphere by volume.	d.	Carbon Monoxide
c	A brown, highly toxic gas formed by the union of nitric oxide and oxygen or ozone.	e.	Carbon Dioxide
		f.	Oxygen
		g.	Sulphur Dioxide

4.3 Results of the Second Seminar

The items developed by the panelists were reviewed by each panel as a group several times during the course of the seminar. The main points covered were: Is the answer clear and correct? Is the item job related? and, How could the question be improved?

At the end of each day test items were collected and secured by Olson Laboratories.

Each panel (light and heavy duty) constructed approximately 300 test items. These were checked, catalogued and combined by test category into an examination data bank by Olson Laboratories. Separate data banks of test items were prepared for the light and heavy duty technicians. These data banks were then used for the test demonstration at the EPA and the third seminar.

SECTION V

ITEM ANALYSIS

The Seminar III began with a review of the past two seminars. The procedures for administering the written exam to the EPA technician and engineers were described and then the technical review panel members were given the examination.

5.1 ITEM ANSWER ANALYSIS

Upon completion of the examination an item analysis was conducted by the Olson team on the examination taken by the panel members. During this time the panel members were asked to document the answer to the test items either by reference to a Federal Register paragraph, an SAE recommended practice or a particular reason for the answer being the most correct. If the answer was not a standard Federal test procedure, the panel members were asked to document the reason for the question such as "acceptable laboratory procedures."

If acceptable laboratory procedures was used as the basis for the correct answer it was usually agreed upon by the panel subgroup and in some cases it was determined by the judgement of the entire panel.

5.2 TEST ITEM ANALYSIS PROCEDURES

After completion of the answer analysis by the panelists they were instructed in test item analysis procedures. The panel members were divided into groups and assigned sections of the exam. Where possible the members were assigned the original Federal Register subparts they had been working on in the previous two seminars.

Instruction in test item analysis covered the following areas:

- Constructing and validating test items.
- Item analysis methods.
- Item difficulty
- Item discriminating power.

After instruction by the Olson team the panelists were given the results of the test item analysis which had been previously prepared by Olson Laboratories they were also given comments made by the technicians and engineers who had taken the test. Also, available to the panelists were comments made by experienced EPA personnel that had reviewed the written examination.

5.2.1 Constructing and Validating Test Items

The validating of an examination depends on the degree with which it measures what it attempts to measure. A test, therefore, should accomplish the purpose the constructor had in mind in order to satisfy this fundamental criterion for testing.

Test validity depends upon (1) the validity of the content in general, and (2) the validity of the individual items of which the test consists. Objective evidence concerning item validities, however, is secured only by, (1) the actual administration of the test in preliminary form to a large group of typical technicians, and (2) a detailed statistical analysis of the results of an item by item review.

The test was administered to a group of technicians and engineers employed by the EPA. This group ranged in experience from one week to several years. Technical and educational background forms were completed by the examinees for the purpose of the test item analysis procedure.

However, this sampling of technicians was not sufficient to statistically determine the test validity. In fact, in order to do this might require administering the examination to a large percentage of the technicians who would in the future be taking the examination for certification and therefore this did not seem to be a practical means of determining test validity.

In some instances content validity is accepted as a demonstration of test validity in skills tests (i.e., tests to determine whether an individual already possesses needed skills or knowledge)[2]. Content validity is evaluated through such devices as job analysis, pooled judgement of competent persons, and item analysis. The only available criterion for validity of the written test is the content validity demonstrated by the procedures used to construct the test.

5.2.2 Item Analysis Methods

Re-examining each item of a test for the purpose of evaluating its strength and weaknesses is known as item analysis. Item analysis customarily concentrates on two vital features of each test item; its level of difficulty and its discriminating power. By the former is meant the percentage of technicians who answer correctly each test item; by the latter is meant the ability of the test item to differentiate

[2] Paragraph 60 - 3.6(12)(b) page 2096

between technicians who have achieved well and those who have achieved poorly.

Item analysis by the Olson team was prepared in three categories for each examination.

1. EPA experienced personnel
2. EPA inexperienced personnel
3. Technical Review Panel

The inexperienced person at EPA was defined to be one with less than six months experience in emission measurement.

The number of responses for each alternative for any test item was listed for each category. Also, listed in this tabulation were the number of unanswered responses and the comments made by the examinee.

The test, in the same form as administered to approximately 40 individuals at the EPA emission facility, was administered to the panel members to (1) provide additional data regarding validity and reliability of the test items, and (2) acquaint the panel members with a more direct insight regarding the individual test items.

In addition to the general instruction of item analysis the panelists were asked to perform the following tasks:

- Items that appeared to be easy or difficult as evidenced by the proportion of correct responses - were eliminated except where the panel felt strongly that the item was critical to the technician's performance.

- Items that could not be shown to be related to the technician's job were eliminated.
- Items which were not preferentially answered correctly by the experienced group were eliminated or rewritten.
- Items whose correct response might depend on the facility policy were eliminated.

Upon completion of the Seminar III the Olson team reviewed the written test eliminating those items as suggested by the panel and rewriting questions which required further technical editing. Olson in an effort to increase the number of multiple choice items re-constructed several of the true-false questions into multiple choice items.

5.2.3 Item Difficulty

Determining the level of difficulty of a test item is a relatively easy task. First a tabulation is made of the number of correct answers. This figure is then divided by the total number attempting the item, and the quotent is multiplied by 100.

The tabulation used for item analysis was also used to determine item difficulty. In general tests contain items of varying degree of difficulty with the average preferably somewhere around 50%. The level of difficulty in this case was determined in order to eliminate a high percentage of items with levels near zero and to improve those questions with levels near 100%. In determining item difficulty those items that had a degree of difficulty of 100% were usually found to be due to incorrect answers or poorly worded questions.

5.2.4 Item Discriminative Power

The basic function of a standardized test is to place individuals along a defined scale in accordance with differences in their achievements. Since the group tested has a varying degree of background, it is possible to determine the discriminative power of the test by comparing the responses from the experienced group with those of the inexperienced. By comparing the responses for the three groups the item could be shown to be job related or answerable by the use of logic or intelligence alone.

5.2.5 Using Item Analysis Results

The results of item analysis can serve two major purposes. The first and more obvious one is that they provide important information concerning the problems encountered when informal achievement tests are built. On the basis of such information, the person preparing the test items can gain a much better view of the worth of the test, and also profiting by his mistakes in that he should be able to construct noticeably better tests in the future. The second use can be summarized by the single word "diagnosis." By examining the data from item analysis, the tester can detect learning difficulties of individual technicians or the group as a whole, and in consequence can plan more suitable training programs. Studying the strengths and weaknesses of technician achievement will also help him to evaluate more accurately the effectiveness of various parts of the learning situation.

5.3 THE WRITTEN TEST DATA BANK

Upon completion of the changes required by item analysis and the technical review panel comments, the written test data bank was again submitted to the EPA for final review.

Comments made by the EPA were incorporated and obvious errors were corrected before the test questions were submitted in final form.

The written data bank of test questions for laboratory technicians in its present form is necessarily only valid for the present procedures prescribed by the Federal Register. As procedures are changed and added to the Federal Register the items will have to be studied and possibly revised to cover these changes. Also new items must be added as new procedures and requirements are introduced, and items which no longer apply must be dropped.

The examinations given in the process of certification of emission technicians should be subjected to analysis in order to improve the examinations reliability and to identify possible areas where the test could be improved.

It is recommended that each time the examination is given that the technical background and evaluation of the examination should also be obtained to aid in the test or item analysis.

SECTION VI

DEVELOPMENT OF A PRACTICAL TEST FOR THE CERTIFICATION OF EMISSION LABORATORY TECHNICIANS

A written data bank of test questions is designed to test the knowledge of a technician. However, a person could have sufficient knowledge to pass the examination without having the required ability to perform the job. In fact many people with experience in taking objective tests can pass a test with only limited knowledge of the subject. Therefore, since the objective of the certification test is for the technician to have both the knowledge and ability to perform emissions test, it is important that not only his knowledge is tested but also his skill in performing an emission test. A practical test for emission laboratory technicians has been developed along the same guidelines used by the Federal Aviation Administration for certification of mechanics.[5] Performance criteria are similar to those generally used in vocational technical training.[6]

The practical test consists of job-related projects assigned to the technician which are designed to test his skill and ability to select and follow correct procedures and to determine an acceptable level of workmanship. An oral test will be administered along with the assigned projects. The questions will be closely related to the job being performed in order to explore further the technician's understanding of the tasks being performed.

The development of the practical test consisted of the preparation of examiner and technician performance guidelines, an examiner task analysis, and a test item form. The task analysis and test item form were delivered to the EPA as a separate document and are not included in the final report.

6.1 EXAMINER GUIDELINES

The object of the practical test is to determine if the technician's performance coincides with the objectives of technician certification. The object is not to see how well the technician retains what he has read in the Federal Register, but to demonstrate acceptable job performance.

6.1.1 Performance Guidelines

In testing of technicians, four types of performance should be considered: discrimination; problem-solving; recall and manipulation.

- Discrimination - The technician is required to make decisions when performing his duties.Whenever he is required to distinguish one thing from another, to determine whether a proper job has been done or needs to be done, or to see the difference between correct and incorrect, the principle type of performance called for is discrimination.

- Problem-Solving - Once the technician decides through discrimination that a job needs to be done, he proceeds to do it. If, for some reason, he is unable to accomplish the job, then finding the trouble is called problem solving. The examiner should test the ability of the technician to determine what to do, should something go wrong with the test, either by contriving a situation or by orally presenting the technician with a situation where some malfunction has occured.
- Recall The technician should be able to follow the proper sequence of the Federal test procedure without the aid of visual aids or the Federal Register. Many of the recall items will be covered in the written exam but there are situations which occur during the test in which the technician has to recall what he has learned in respect to what to do and when to do it situations. Some examples are checking flowmeters, spanning instruments, and draining traps.
- Manipulation - Testing manipulation involves the technician's skill in performing the job. The examiner should determine the technician's proficiency

in performing the various tasks assigned to him as part of the test. Some examples are driving the cycle, aligning the engine dynamometer, and measuring exhaust concentrations.

6.1.2 Subjective Testing

The practical test is a subjective-type and consists of both a manipulative and oral test. They differ from the written objective test in that judgement is required in determining the proficiency of the test technician. The manipulative test deals mainly with the technician's performance in problem solving and manipulation; whereas the oral deals more with his ability of discrimination and recall.

6.1.3 Examiner Qualifications

The examiner should be experienced in the most recent state-of-the-art testing procedures. He should have performed tasks which he will be requesting the technician to demonstrate. Without this experience, the examiner may make a judgement based on closely defined criteria which may not allow for the difference in training and experience of the technicians being tested. For example, a driver might be failed by an examiner who has never driven the test, if he makes one driving error during the cycle. Judgement of this situation should have been based on:

- How well did the driver perform on the balance of the cycle?
- What has been his experience with driving this type of vehicle?
- Is the vehicle representative of the population or does it represent only a very small percentage?
- Did the driver know he had made a mistake?
- What is the extent of his driver training and experience prior to the test?

In other words, the objective is to determine if the driver would normally be able to drive a valid test and to know what makes a test invalid, not that he must be "error-free" in every test cycle he drives.

The examiner must not be biased by past experience with the test facility. He must remember he is testing an individual, and his judgement should be based only on the performance of the individual rather than the complete laboratory.

The technician should be given every chance to answer the oral questions correctly; and the "correct" answer must be based on the scope of his particular job.

6.2 GENERAL EXAMINATION INSTRUCTIONS

The person administering the manipulative test will explain each of the projects assigned during the practical test and give some indication of the level of performance acceptable. The examiner should describe the scoring and the scope of test completely before the test is given. The examiner should explain the fact that he will judge the technician's performance not only on the use of acceptable laboratory practices, the knowledge of basic operation of the equipment being used, and observance of safety rules.

The oral test may be administered along with the practical test in the form of questions about the projects being performed. The examiner should not attempt to trick or mislead the technician in any way with his oral questions or project assignments.

6.2.1 Manipulative Test

The projects or tasks to be assigned to the technician have been outlined in the task analysis section. Essentially these tasks comprise most of the duties the technician is responsible for in the performance of an emission test. The examiner may require completion of the tasks using a few oral questions, or, if he chooses, use only some of the tasks outlined and increase the oral quiz. Tasks normally performed by the technician should be covered either by a practical or oral test.

The examiner should select the tasks he wants the technician to perform and determine the extent to which the task must be performed. This decision should be based on the technician's job description, if available, and his training in the operation of the equipment being used. Also, the availability of support services within the company, such as calibration and maintenance, must be taken into account. No task should be assigned which is normally done by a support group or someone other than the technician.

6.2.2 Oral Test

Since this is a subjective rather than an objective test, the questions should pertain to the specific operation being performed by the technician. The examiner should ask his own questions which are related to the test objectives and the unique type of operation used at the particular facility where the test is being given. The examiner should direct his questions to the technician's ability to discriminate and recall (i.e., the ability to know what to do, when to do it, and why). Knowing how to decide what tasks and how to perform the tasks is covered in the practical test.

The oral test can be more flexible than the practical test. Questions may be asked about portions of the procedure not normally performed by the technician in order to demonstrate his understanding of the overall operation of the test facility (e.g., computer functions which start and stop the test at a particular time, or what might be expected if certain parts of the system were to malfunction). Questions of this nature should not be too technical or beyond the skill level of the technician.

6.3 PRACTICAL TEST EXAMINER TASK ANALYSIS

A task analysis has been prepared to describe in detail the tasks performed by the examiner. This task analysis, derived from the task analysis prepared for the technician, was submitted to the EPA as part of the practical examination.

The task analysis was used as a guideline in detailing procedures and in developing the test item form (s) to be used by the examiner. The task analysis also includes the projects assigned to the technician. In addition, the task analysis may be used to determine scoring procedures to be used by the examiner. The more critically evaluated tasks should comprise a greater percentage of the score

6.4 DATA REDUCTION AND DURABILITY TESTING

The areas of data reduction and durability testing are seldom performed by the technicians who will be tested. These are covered in the written exam and do not readily lend themselves to a practical test.

The examiner will decide if the technician should be required to perform calculations of emission data or durability factors; and consequently these were not included in the task analysis. These areas would be best covered in a total laboratory certification.

6.5 TEST ITEM FORM

The item form serves two purposes; a checklist of the tasks to be performed and a mechanism for scoring the examination. Essentially it is a list of the manipulative test items with an accommodation for scoring the oral test.

The recommended grading procedure utilizes the importance of the task element in assigning points. This by necessity has been determined using the best judgement of those preparing the item form. In scoring the test the examiner should consider that the total score for accomplishing only moderately important elements of the task should not be sufficient for a passing grade.

As with the written examination the test item form will have to be updated as procedures and requirements change. An example of the form is presented in Appendix E.

SECTION VII

REFERENCES AND SELECTED BIBLIOGRAPHY

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APPENDIX A

JOB ANALYSIS

SEMINAR I HANDOUT

APPENDIX A

The Development Of Written Tests For Certification Of Emissions Laboratory Technicians

Seminar I Handout October 23, 24, 25,1973

JOB ANALYSIS

Basically, there are but three parts to the analysis of any job: (1) The job must be identified completely and accurately; (2) the tasks of the job must be described completely and accurately; (3) the requirements the job makes upon the worker for successful performance must be indicated.

The categories of information that must be obtained and reported in order to meet the requirements for a complete anaylsis of a job are four in number and have been formalized into a measurement device that is designated as the "Job Analysis Formula." These four categories are: "What the worker does," "How he does it," "Why he does it," and "The skill involved in doing."

Before a job analysis can be of value in any program, it must indicate the exact nature and scope of the tasks involved in a job and define the level of difficulty of those tasks. The first three parts of the Job Analysis Formula, the "What," "How," and "Why," bring out the nature and scope of the tasks. The last part of the formula, the "Skill Involved," measures the degree of difficulty of the tasks and exactly defines the nature of the required skills in order to indicate their difficulty.

PRINCIPLES IN THE ANALYSIS OF JOBS

The term "job" is used in many different ways and has different meanings to the individuals using the term. Because such terms as "job," "position," "task," and "duty" are so often used interchangeably, and with resulting confusion, it is necessary to establish somewhat arbitrary meanings for them. The following terms are significant for an understanding of basic job structure and job analysis:

1. ELEMENT is the smallest step into which it is practicable to subdivide any work activity without analyzing separate motions, movements, and mental processes involved. It is a work unit that describes in detail the methods, procedures, and techniques involved in a portion of the job.

2. TASK or DUTY, made up of one or more elements, is one of the distinct major activities that constitute logical and necessary steps in the work performed by the worker. It is the work unit that deals with the methods, procedures, and techniques (the "What," "How," and "Why") by which parts of a job are carried out. A task or duty is created whenever human effort, in terms of one or more elements, must be exerted for a specific purpose. The effort may be physical, as pulling and lifting, or mental, as planning and explaining. The effort may be exerted to change a material or merely to maintain the status quo of a material. The material may be tangible, as boards and nails, or intangible, as numbers and words. Each task or duty has certain distinguishing characteristics.

(a) It is recognized, usually, as being one of the worker's principal responsibilities.

(b) It occupies a significant portion of the worker's time.

(c) It involves work operations which utilize closely related skills, knowledges, and abilities.

(d) It is performed for some purpose, by some method, according to some standard with respect to speed, accuracy, quality, or quantity. This standard may be provided by the worker himself through trial and error or as a result of experience; it may be furnished to the worker by his supervisor in the form of oral, written, or graphic instruction; or it may exist in the form of directives, published operating procedures, or similar media.

Tasks or duties may be considered major or minor, depending on the extent to which they establish demands for skills, knowledges, aptitudes, physical capacities, and personal traits and upon the percentage of total work time involved in their performance.

3. POSITION is an aggregation of tasks or duties with related responsibilities. Each position has characteristics which distinguish it and by which it may be recognized.

(a) It has a definite scope and purpose.

(b) It requires the full-time service of one worker.

(c) It involves work which utilizes related skills, knowledges, and abilities.

4. JOB may be defined as a group of positions which are identical with respect to their major or significant tasks and sufficiently alike to justify their being covered by a single analysis.

WORK PERFORMED

Generally, in describing the tasks that comprise a job the analyst should arrange them in either a chronological or a functional order. Tasks can be arranged chronologically when a job has a specific cycle or sequence of operations. The analyst should describe the tasks the worker is called upon to do in the order in which he performs them. Applied to some machine-type jobs, the tasks could be arranged in the following order:

1. Sets Up Machine
2. Mounts Work Piece
3. Operates Machine
4. Removes Work Piece
5. Inspects Work Piece
6. Maintains Tools
7. Maintains Machine

The next part of the Job Analysis Formula, the "Skill Involved," must also be carefully considered in presenting each job task. The "Skill Involved" consists of such factors as Responsibility, Dexterity and Accuracy, and Job Knowledge, all of which will be considered in the Performance Requirements section. Whenever possible, the Work Performed must be so worded that the "Skill Involved" in the tasks can be directly related to the Performance Requirements.

PERFORMANCE REQUIREMENTS

The Performance Requirements are covered by four specific factors:

Responsibility
Job Knowledge
Mental Application
Dexterity and Accuracy

Responsibility:

This factor relates to the degree of supervision received and exercised, the number of checks set up to prevent or catch errors, the decision limits within which a job must conform, and the degree of loss that would result from error, or the saving that would be effected by foresight.

The major considerations affecting this factor are:

1. Does worker delegate work to others? How? To Whom?
2. Does worker coordinate the efforts of subordinates? How?
3. Is worker accountable for progress, quality, and costs of work?
4. Does worker train others? Whom?
5. What are the nature and the magnitude of supervisory control?
6. Does work require contacts with outsiders or others in the organization not in line of authority? Of what nature and with whom?
7. What are the nature and the scope of commitments made?
8. To what extent is work verified by others?

Jobs must be examined for the relative amount of each of these considerations as well as their presence.

Job Knowledge:

This factor refers to the practical knowledge of equipment, materials, working procedures, techniques, and processes required of the worker for the successful handling of a job. The practical knowledge requirement includes that which must be acquired after appointment to perform efficiently the work tasks, as well as that which must be acquired as a prerequisite to appointment.

Job knowledge includes all of the knowledge required of the worker by the job, whether that knowledge is gained by actual on-the-job experience, by academic courses of training prior to entry on the job, or by both. When thinking of this factor, consideration should be given to a variety of specifications, materials, and assignments encountered, and guidelines governing decisions and operations, such as precedent, regulations, standards, and practices. Consideration should also be given to such points of pre-employment or on-the-job knowledge as:

1. Knowledge of machines and equipment used.
2. Knowledge of materials used.

3. Knowledge of working procedures and techniques.
4. Knowledge of product flow or process as related to the job.
5. Knowledge of dimensional or formulary calculations.

Mental Application:

"Mental Application" refers to the exercise and maintenance of mental processes required to perform properly the duties of a job. It may be stated as the degree and continuity of thought, mental planning, or mental alertness that must be exercised in performing an operation. It includes mental concentration required because of diversity of work or variety of problems.

Considerations affecting this factor are:

1. Initiative, which refers to the need to face and solve new problems. This involves mental resourcefulness, analytical ability, the making of decisions, and the taking of independent action and should be considered according to the probable frequency of occasions on which the job will require it outside the control or routine of supervision.

2. Adaptability, which refers to the versatility required of the worker or the need, or lack of need, for the worker to handle adequately quick changes in assignment or to carry on several tasks simultaneously.

3. Judgment, which refers to the amount of independent decisionmaking that must be exercised by the worker in performance of a job. The importance of the results obtained by such independent decisionmaking or the extent of the consequences of poor judgment must be considered.

4. Mental alertness, which relates to the attention necessary to tend and feed a machine properly, attention which must be given to orders, and alertness necessary to prevent damage to equipment and materials or injury to personnel.

Dexterity and Accuracy

This factor refers to the manual or manipulative ability required to perform given work to a required degree of accuracy or precision and to the complexity or intricacy of manual processes involved. The elements to be considered here are characteristics such as the dexterity, accuracy, coordination, expertness, care, and deftness required in manipulating,operating, or processing the materials, tools, instruments, machines, or gages used. The number of units of work normally produced in a given period of time is also a measure of dexterity.

The major considerations affecting this factor are:

1. Dexterity, which relates to the quickness or deftness required, or the coordination of sight or other senses with the muscles.

2. Accuracy, which relates to the degree of precision required in the handling of product or materials and for the adjustment and manipulation of equipment and tools to the required degree of precision.

APPENDIX B

TASK ANALYSIS

B-1 Light Duty Vehicles

B-2 Heavy Duty Engines

TASK ANALYSIS

B-1 Light Duty Vehicles

THIS TASK ANALYSIS SHOULD NOT BE USED AS A SUBSTITUTE FOR THE FEDERAL REGISTER. IT WAS USED AS A WORKING TOOL TO DEVELOP THE EXAMINATION QUESTIONS, THEREFORE, CORRECTIONS AND OMISSIONS NOTED BY THE PANELISTS IN A REVIEW OF THE TASK ANALYSIS WERE NOT INCLUDED IN THIS DRAFT COPY.

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Vehicle Preparation (1) Test Procedures (2) Evaporative Emissions Preconditioning (1) Subpart A&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
1, 5	Preconditioning of vehicle	° Inspect vehicle and record VIN and other identification such as vehicle or test	5	1	5
		° Drive vehicle for one hour over approved route	5	1	3
		° Return vehicle to soak area	5	1	1
1, 5	Evaporative Emissions Pretest	° Vehicle Prep Fuel tank vents prepared to accept canister Inspect fuel system for leaks Install fuel tank thermocouples Install tank fittings to drain fuel Weigh canisters and record	5	4	5
		<u>Task: 1.1.2.2 A.C.</u>			
1, 5	Diurnal Breathing Loss Test HOT L.A. 4 → SOAK 1 hr. @ 76°F-86°F	<u>(Fuel Evaporative Emissions Collection Procedure</u> ° Vehicle conditioning over approved test route ° (one hour) Check tire inflation ° Soak period 10 hours at 60° - 86°F ° Vehicle transferred to soak area at 76° - 86°F ° Vehicle fuel tank thermocouples connected to recorder fuel and ambient air temperatures recorded (12 in./hr.) ° Vehicle fuel tank drained ° Recharge fuel tank with specified test fuel prescribed tank volume (40 pct. tank vol.) Avoid abnormal loading of evap. emission control system ° Exhaust pipe(s) and inlet pipe to air cleaner plugged ° Install preweighed vapor collection system(s) ° Install heating blanket or other heating device ° Heat the fuel in the tank to 84° $\pm 2°F$ FROM 60°F ± 2° Record temperatures over a period of 60 $\pm$ 10 min constant rate heat input ° Move test vehicle onto preset preconditioned dynamometer.	5	3	3-5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Vehicle Preparation (1) Test Procedures (2) Evaporative Emissions Preconditioning (1) Subpart A&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
		° Remove or disconnect fuel tank heat source Remove plug from vehicle exhaust pipe(s) Remove plug from inlet to air cleaner Reconnect thermocouples and record temperatures.			
1, 5	Hot Soak Test	° After completion of driving schedule Turn off cooling fan - close engine cover compartment Replug exhaust pipe Replug inlet to air cleaner ° Permit vehicle to hot soak for one hour ambient temperature 76° - 86°F ° Completion of test: Disconnect vapor trap(s) Reweigh vapor trap(s) (nearest 0.01 grams) Record weight net gain in trap(s).			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Vehicle Test Driver (2) Test Procedures (2) Preconditioning (1) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
1, 2, 5	Chassis Dynamometer Preconditioning	<u>Task 1-2-2-1 A,B,C,</u> ° Drive non-test "warmed up" vehicle onto dynamometer rolls ° Secure the vehicle with chocks or chains ° Drive "cold" dynamometer at 30 MPH for 15 minutes to "condition" the equipment ° Set dynamometer road load horsepower (50 MPH) and equivalent inertia as specified for next test vehicle ° Remove non-test vehicle from dynamometer rolls ° Check drivers aid for paper, ink and zero of indicator pen	5	3	3-4
1, 2, 5	Cold Start Emissions pretest	° Push emission test vehicle onto preset dyno rolls ° Secure test vehicle with chocks and chains. ° Check and/or adjust tire pressures. ° Check fuel type and quantity. ° Connect sampling system for emission test (Leak test modal sampling system if used) ° Place cooling fan in front of vehicle ° Start cooling equipment ° Span and zero drivers aid ° Connect vehicle tailpipe to CVS	5	1	5-4
		° Disconnect and clamp loss measurement traps Where evaporative emissions would be inducted into the engine. ° Measure fuel tank temperature and record ° Record ambient temperature, barometer, time, date, humidity, test number, driver, operator Vehicle-make, model, model year, trans, odometer, engine, displacement, family, fuel system, tank capacity, tank location, number of carbs, number of barrels, inertia loading, road load horsepower @ 50 MPH drive wheel pressure	5	3	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Vehicle Test Driver (2) Test Procedures (2) Preconditioning (1) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
		° Connect RPM monitoring device ° Connect auxiliary fuel supply to fuel pump and return lines if used			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Test Driver (2) Test Procedures (2) Calibration Dyno (7) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
1.2.5.	Chassis Dynamometer calibration #1	° Appendix II and CFR 38/124, 85.074 (e)			
		° Warm-up dynamometer according to manufacturer's specifications (30 mph - 15 minutes)	1	3-5	4-5
		° Verify speed and horsepower meter calibrations (strobe or equivalent method for rolls speed, weights for load cell calibration or equivalent)	1	5	5
		° Coastdown should be run for all vehicle weights that might be tested on the dynamometer		3	5
		° Engage inertia for vehicle weight class			
		° Drive dynamometer rolls to 50 mph			
		° Set indicated road load horsepower, for example, 2.5, 5.0, 7.5 and 10.0 HP are points in the range of normal useage		3	
		° Drive dynamometer to approximately 60 mph			
		° Disengage the device used to drive the rolls			
		° Record time for the dynamometer drive rolls to coast from 55 mph to 45 mph (3 to 5 replications)		5	5
		° Repeat procedure for all of the 4 HP settings at each inertia weight			
	Calculate	° Calculate absorbed road load horsepower	1	5	5
		° Determine linear least square fit for each inertia weight		3	5
		° Determine HP set points to nearest ~~.5 (or .2)~~ 0.1 horsepower			
	Chassis Dynamometer Calibration # 2	° 85.073-15 (e)			
		° On a level road, start at 20 mph and at 5 or 10 mph increments, determine absolute manifold pressure (or differential pressure on each representative vehicle (mean of both directions)	1	3-5	5
		° Repeat on dynamometer			
		° Adjust dynamometer parameters to reporduce the road curve as nearly as possible as well as match the horsepower at 50 mph		5	5
		° Allow minimum of 8 hours breakin of dynamometer breakin after major maintenance (belt or bearing replacement)			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Test Driver (2) Procedures (2I Cold Start (2) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
2, 5	Cold start test dyno	° Set choke per manufacturers recommendations and be aware of specific manufacturers operating procedures for the particular vehicle.	5	5	5
		° Simultaneously crank engine, start pump revolution counter, sample collection and temp recorder		1,3,5	
		° When engine starts - then start driving schedule (start drivers aid when engine starts)			
		° 15 seconds after engine starts, place transmission in gear			
		° 20 seconds after engine starts, begin initial vehicle acceleration			
		° Follow dynamometer driving schedule using a minimum amount of throttle and braking with right foot driving only			
		° At 505 seconds - cold transient phase ends 1) Signal or switch from transient sample to stabilized sample bags 2) Switch off revolution counter #1 3) Switch on revolution counter #2			
		° At 1369 seconds which is 2 seconds after last deceleration - turn engine off			
		° 5 seconds after engine off-stop sampling			
		° Disconnect sampling system from vehicle			
		° Turn off cooling fan		3	3
		° Close engine compartment cover		3	3
2, 5	Hot start test Dyno	° Soak the vehicle for 10 minutes (within ±1 min)	5		5
		° 8-10 minutes after end of cold start 1) Open engine compartment cover			
		2) Start cooling fan		3	
		3) Connect sampling system to vehicle tailpipe 4) Start CVS positive displacement pump and preheat heat exchanger			
		° With throttle depressed half way or by manufacturers specific procedure for Hot Start			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Test Driver (2) Procedures (2) Cold Start (2) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
		Simultaneously: Crank engine, start revolution counter, sample collection for hot transient sample and ambient sample. ° When engine starts-start drivers aid ° Fifteen seconds after engine starts place transmission in gear ° Twenty seconds after engine starts begin acceleration ° Follow driving schedule ° At 505 seconds: Turn-off revolution counter Position sample selector valve to dump position ° Turn off cooling fan and close engine cover ° Remove sampling system from vehicle ° Remove vehicle from dynamometer and move to soak area ° Reconnect evaporative collection equipment and close engine compartment cover ° Collect and complete all data pertinent to the test ° Assign driveability rating to vehicle			
2, 5	3 Speed Manual Transmission	° Idles shall be in gear with clutch disengaged ° Vehicle should be shifted at 15 & ~~20~~ 25 unless otherwise specified by the manufacturer ° Decels shall be made with clutch engaged and in the last highest gear using the brake and throttle to maintain the desired speed ° Clutch should be depressed at speeds below 15 MPH or when engine stalling is imminent ° Downshifting is allowed on a power mode if recommended by manufacturer or if engine lugging is obvious	5	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Test Driver (2) Procedures (2) Cold Start (2) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
2,5	Four and Five Speed Transmission	Driving procedure Four and Five Speed Manual Transmissions ° Use same procedure as for 3 speed shifting from 3-4 at 40 MPH unless otherwise specified by manufacturer ° Fifth gear may be used at manufacturers option ° If transmission ratio exceeds 5:1 do not use 1st year. Use 2nd, 3rd and 4th as 1st-2nd-3rd	5	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Test Driver (2) Procedure (2) Cold Start (2) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
2, 5	Engine Stalling and Restart	Engine Starting	5	5	5
		° If vehicle does not start after 10 seconds of cranking, cranking shall cease, revolution counter stopped, and sample valve placed in'bypass'			
		° Tailpipe disconnected		3	
		° Fan stopped		3	
		° Reason for failure to start determined		5	
		a) If failure is operational error, vehicle shall be rescheduled for retest			
		b) If failure to start is caused by vehicle malfunction, it may be corrected within 30 minutes and the test resumed 1. Reset choke (if cold) 2. When cranking starts, the sampling system should be reactivated 3. When the engine starts, the drivers schedule should be started			
		c) If vehicle still does not start after correction, the vehicle is removed corrective action taken and rescheduled			
		Engine Stalling	5	5	5
		° False Starts If engine false starts, the operator shall repeat the starting procedure			
		° Stalling ° If engine stalls during an idle period, the engine shall be restarted immediately and the test continued. ° If engine cannot be started in time for the next acceleration, the schedule indicator shall be stopped, when the vehicle restarts the schedule indicator shall be reactivated ° If engine stalls during some operation mode			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Test Driver (2) Procedure (2) Cold Start (2) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
		other than idle - the driving indicator shall be stopped. When the vehicle starts, it shall be accelerated to the speed required and then the driving schedule and the test continued. If vehicle will not restart within one (1) minute, the test shall be voided.			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Data Analyst (3) Data Reduction (4) Calculations (4) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
3.4.5	Data Reduction Chart Reading	<u>Chart Reading Exhaust Emissions:</u> ° Determine emission concentrations Diluted exhaust sample Dilution air sample Use appropriate calibration curves/charts ° Determine average dilute exhaust temperature from Temperature recorder chart	5	4	4
	Data Reduction	<u>Calculations</u> ° Dilute sample emissions concentrations Correction for background emissions ° Determine total dilute exhaust volume at standard conditions ° Apply barometric correction to humidity factor ° Resolve differences between dilution factor and dilution ratio ° Final reported test results light duty vehicles ° Final reported test results for off-road ulitity vehicles			
	Data Reduction	<u>REDUCTION OF EVAPORATIVE EMISSION TEST DATA</u> ° Fuel evaporative emission losses The net gain, grams of the individual collec- tion - traps are added together to determine fuel evaporative emission losses, grams per test			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Data Reduction Analyst (3) Data Reduction (4) Calculations (4) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
3,5,6	Reduction Of Vehicle Durability Test Data	° Vehicle emission test data ° Vehicle emission data from tests conducted before and after maintenance ° Plot all applicable test results as a function of test mileage ° Determine best fit straight line by method of least squares (Do not use zero mile data) ° Interpolate 5,000 and 50,000 mile data for HC, CO, & NOx ° Calculate deterioration factors for HC, CO, & NOx per applicable Federal Register TASK: 1-(1,2,3,4)-1-8-A,B,C Terminology: See Def. + Abb in FR	5	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Test Procedures (2) Pretest Preparation (1) A,B,C, TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
		<u>1-4-2-1 ABC</u>			
4,5	Sampling Pretest Preparation - CVS	° Preheat heat exchanger of the Constant Volume Sampler	5	3	3
		° Selector valve in dump or standby position			
		° Connect evacuated sample bags for dilute exhaust samples For dilution air samples			
		° Leak check CVS (from probe to bag)	4	3	5
		° Insure that CVS is at operating test temperature	5	2	5
		° Purge CVS bags, Check CVS flow rates. (Dual purge is recommended)	5	2	5
		° Change filter	4-5	2-3	5
		° Start CVS pump (blower) at normal operating speed	4-5	1	5
		° Verify that CVS is at operating temperature	5	1	5
		° Turn on sample pumps and check flow rates (minimum of 10 scfh)	5	1	
		° Start temperature recorder to record CVS pump inlet temperature	5	1	3
		° Start pump revolution counter, sample pump and start sample collection at start of engine cranking	5	1	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Instrument Pretest Procedures (2) (1) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4, 5	Instruments Pretest Calibration	° Adjust analyzers to optimize performance	4	3	3
		° Change sample filters	4	1	1
		° Leak check system	5	1	5
		° Zero the analyzer (HC, CO, CO_2, NO_x) meter CO, CO_2, NO_x - N_2 or zero air HC - zero air only	5	3	5
		° Zero each analyzer and recorder or DVM	5	5	5
		° Select optimum instrument ranges	5	5	5
		° Flow span gases at normal operating flows and pressure. (Same flow rate as for zero gas)	5	3-5	3-5
		° Indicate concentrations on recorder chart	5	3-5	3-5
		° All exhaust emission analyzers are comparative devices. In order that the comparison be valid, the flow rate during measurement of the sample (unknown) must be the same as the flow rate during calibration			
		° Adjust analyzer gains to analyzer calibration curves.	5	3-5	5
		° Recheck analyzer meter, recorder, zero and span			
		° Recommend use of midspan gas to verify calibration curve for non-linear analyzers.	5	3-5	5
		° Re-flow zero gas	5	3-5	5
		° NO_x converter and sample conditioning system efficiency will be covered under system maintenance.			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Test Procedures (2) Instrument Analyses (3) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4.5	Instrument analysis Bag Samples	° Connect background bag	5	3	5
		° Turn on analytical sample pump	5	1	5
		° Set proper flows and/or pressures	5	1	5
		° Record concentrations on chart	5	1	5
		° Disconnect background bag and connect sample bag	5	1	5
		° Set flows and/or pressures	5	3	5
		° Recorder charts - identify calibration points for zero, midspan and span gases. Indicate bag sample traces and identify each for each test phase. Record chart speed.	5	3	5
		° Record deflections on data reduction forms	5	3	5
		° Check zero setting on each analyzer	5	1	5
		° Check span setting on each analyzer	5	3	5
		° Allowable zero and span drift ± 1% F.S.	5	3	5
		° If drift exceeds tolerance recalibrate and reanalyze background and sample bags	5	3	5
		° Bags must be analyzed within 20 minutes after test	5	3	5
1.2.3.4	Information To Be Recorded	REQUIRED DATA EACH TEST Test number System or device tested Date and time of test schedule Instrument operator and test driver Vehicle make and VIN Model year Transmission type Odometer reading Engine displacement Engine family Idle RPM Inertia loading Estimated curb weight Actual roadload HP at 50 mph Drive wheel tire pressure	5	2-3	4-5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Test Procedures (2) Instrument Analyses (3) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
1.2.3.4 (Cont.)	Information To Be Recorded (Cont.)	Dynamometer serial number Indicated roadload power absorption at 50 mph Instrument information or cell number upon approval of adminstration Tuning Gain Serial numbers Detector numbers Range Recorder charts or computer output sheet Indentify zero Span gas Exhaust gas Dilution air Test cell barometric pressure Ambient temperature Humidity based on wet and dry bulb temperatures Inlet pressure at positive displacement pump Pressure increase across pump Temperature set point of temperature control system The number of revolutions of positive displacement pump accumulated during each test phase Humidity of dilution air based on wet and dry bulb temperature measurements. based on interference levels of CO instrument utilized Temperature set point of heated sample line Temperature set point of heated hydrocarbon detector			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Test Procedures (2) Pretest (1) Subpart B TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4, 5	Instrument Pretest Calibration	<u>Task 1.4.2.1 B</u>			
		° Allow HFID heater to reach stable temperature	5	5	5
		° Set sample capillary flow rate			
		° Zero and calibrate as in Subpart A and C			
		° Check response time of HFID 90% full scale 1 second-instrument responses transport time 4 seconds maximum	3	3	5
		° Set hydrocarbon integrator counter to zero	5	1	5
		° Start integrator, HFID sampling, and recorder at start of cranking.	5	1	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Test Procedures (2) Instrument Analyses (3) Subpart B TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Instrument Analyses - HFID	° At end of 505 seconds transient phase switch off hydrocarbon integrator No. 1 mark hydrocarbon recorder chart ° Start hydrocarbon integrator No. 2 simultaneously ° 5 seconds after engine stops, mark hydrocarbon recorder chart and stop hydrocarbon integrator No. 2 ° Reset hydrocarbon Integrators to zero ° Start sampling integrator and mark HFID recorder at start of cranking ° At end of deceleration at 505 seconds mark HFID recorder and stop integrator	5	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Analytical Systems (3) Instrument Analyses (3) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4.5	Cold Start Test Sampling	° Start CVS sample pumps, recorders and reset counters. Bag sample valve in bypass position	5	3	5
		° Start pump revolution counter, start timer, and sample collection at the beginning of engine cranking	5	3	5
		° Verify bag flow rates	5	3	5
		° During idle periods observe inlet and outlet pressure of CVS pump and record on test data form	5	3	5
		° Observe and record temperature of diluted exhaust between heat exchanger and positive displacement pump	5	3	5
		° Observe and record wet and dry bulb temperatures during test	5	3	5
		° Observe barometer and record pressure	5	3	5
		° Cold start transient phase ends at 505 seconds of driving schedule. Switch from transient phase sample bags to stabilized phase sample bags	5	3	5
		° Switch off pump revolution counter # 1	5	3	5
		° Start pump revolution counter # 2	5	3	5
		° Disconnect transient phase dilute exhaust and dilution air sample bags	5	3	5
		° Transfer bags to the analytical system and process the samples within 20 minutes	5	5	5
		° Turn the engine off 2 seconds after end of last deceleration (at 1369 seconds) five seconds after engine stops: (For 1975 cold start)	5	3	5
		° Turn off pump revolution counter # 2	5	3	5
		° Position sample solenoid in "dump" position	5	3	5
		° Disconnect the stabilized phase dilute exhaust and dilution air sample bags	5	1	5
		° Transfer bags to the analytical system and process the samples within 20 minutes	5	5	5
4,5	Hot Start Test Sampling	° Connect sample bags for diluted exhaust and dilution air samples for the 505 second hot start test	5	3	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Analytical Systems (3) Instrument Analyses (3) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4.5 (Cont.)	Hot Start Test Sampling (Cont.)	° Position solenoid valve in "dump" position	5	3	5
		° Start positive displacement pump and sample pump, heat exchanger temperature recorder	5	1	5
		° Adjust sample flow rates	5	1	5
		° Evacuate bags and leak check system	5	1	5
		° Reset positive displacement pump counter (to zero)	5	1	5
		° Connect sampling system (flexible exhaust pipe) to tail pipe	5	1	5
		° Start the positive displacement pump (10 minutes) after end of cold start test	5	1	5
		° Direct the sample flows to the hot start transient phase sample bag and transient dilution air sample bag	5	3	5
		° At end of deceleration 505 seconds of driving schedule:	5	5	5
		° Turn off pump revolution counter # 1	5	5	5
		° Position selector valve in "dump" position	5	5	5
		° Disconnect hot start transient dilute exhaust and dilution air bags	5	1	5
		° Transfer the bags to the analytical system and process the samples within 20 minutes	5	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Systems (3) Maintenance (5) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Efficiency Check Of CO Sample Conditioning System	° Zero and span the CO analyzer on the most sensitive scale ° Recheck zero on meter and recorder or computer ° Bubble a 2% CO_2 span gas through water and then through the sample conditioning system to the CO analyzer A CO instrument response of more than 2% full scale indicates that a conditioning column requires replacement If instrument response is excessive with new drying towers (columns), change drying towers or add filters. If excessive response is constant, correct all reading accordingly	1,5	5	5
4,5	NOx Converter Efficiency Check	OXIDES OF NITROGEN TO NO CONVERTER EFFICIENCY ° Pass NO/N_2 span gas to NOx analyzer (through converter bypass) Record the concentration of NO span gas on recorder chart, ppm ° Blend oxygen into NO/N_2 span gas to reduce NO concentration about 10% on recorder chart, record this concentration, ppm ° Turn on ozonator and increase supply voltage until NO concentration is reduced to 20 % of diluted span gas ° Maintain at least a minimum of 10% of NO concentration of diluted span gas, record NO concentration , ppm ° Switch flow through converter and record NOx reading ° Turn off ozonator power supply, allow analyzer reading to stabilize ° Record the NOx analyzer reading, ppm	3,1	4,5	4,5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Systems (3) Maintenance (5) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	NOx Converter Efficiency Check (Cont.)	° Close oxygen supply valve, check concentration of NO span gas, ppm ° Calculate the efficiency of the NOx converter ° The efficiency of the converter should be greater than 90 % ° Adjust converter temperature as required	3,1	4,5	4,5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) CVS System (3) Calibration (7) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4, 5	Calibration CVS	<u>Constant Volume Sampler Flow Calibration by Laminar Flow Element</u> ° Determine CVS pump inlet depression ° Attach flow restrictor upstream of CVS pump ° Attach LFE upstream of flow restrictor ° Monitor the following data at various pump pressure settings (settings made with flow restrictor). Barometric pressure, LFE ΔP, T at LFE inlet, LFE Inlet Pressure, T at Blower inlet, wet bulb & drybulb temperature for Humidity correction, CVS pump ΔP, P at blower inlet, and CVS revolution count. Determine V_o by equation $V_o = \frac{Q\ T_p}{M\ \ 528}\ \frac{760}{P_p}$ n = rev count/min q = ft^3/min Tp= T at pump inlet in °R Pp= Pump inlet pressure mm,Hg	1	5	5
		<u>Alternate CVS Calibration Procedure</u> ° Use dry gas meter (rotating lobe meter). Calibration may be more easily traceable to NBS standard.	1	5	5
4, 5	CVS Calibration Verification	<u>Constant Volume Sampler Verification</u> ° Zero and calibrate hydrocarbon analyzer (FID) on range normally used for vehicle sample analysis. ° Place in standby position for CVS propane injection test. Note: CO may be used instead of propane, but it is less popular due to high toxicity of pure CO and you must use larger containers because of its gaseous state. ° Operate CVS in normal manner, measure pump inlet pressure and temperature. Use purged sample bags	1,3,4	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) CVS System (3) Calibration (7) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
		° Accurately weigh small cylinder of propane Use instrument grade propane ° Start pump revolution counter, selector valve to sample position. ° Inject a quantity of cylinder propane uniformly into the system over a 14 minute period. Stop propane injection, sample for another minute, then stop sampling. Reweigh cylinder of propane. ° Determine hydrocarbon concentration of bag sample. ° Determine total dilute propane volume in cubic feet per test corrected to standard conditions ° Compare weighed versus calculated propane amounts. ° Calculate error $\text{Test error} = \frac{(\text{CVS grams} - \text{weighed grams})}{\text{weighed grams}} 100$ ° If test error is greater than ±2% resolve problem.			
4, 5		<u>CVS Verification with a CFO (Critical Flow Orifice)</u> A calibrated critical flow orifice can be used to meter 100% propane into a CVS. Bag sample and CFO measured propane amounts can be compared, and error determined as above.	1	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Analytical System (3) Calibration (7) Subpart A,B,C, TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Instrument Calibration	° Calibrate the instrument consol once a month or as needed Hydrocarbon analyzer ° Warm-up according to manufacturer's specs ° Determine air, fuel & sample pressure for optimine performance ° Adjust analyzer sample capillary flowrate and pressures ° Select the desired ranges ° Adjust so that zero is same for all ranges used ° Zero the meter and recorder ° Calibrate the analyzer with propane/air diluent calibration gases of propane concentrations of 25, 50, 75 and 100 percent of full scale. Meter and recorder (at least 4 gases must be used to demonstrate linearity.) ° Concentrations of the calibration gases must be known within $\pm$ 2% ° Determine the oxygen response of FID with the following blend gases. Approximately 100 ppm propane in each of the following: 21% O_2, balance N_2; 19% O_2, balance N_2; 17% O_2, balance N_2; 15% O_2, balance N_2; 10% O_2, balance N_2; 5% O_2, balance N_2; 0% O_2, balance N_2. Plot percent error vs. oxygen concentration. Percent error must not exceed 2% for Oxygen concentration normally found in bag samples. If error excessive fix or change detector. ° Recheck zero and span data with previous calibration chart and/or curves ° Place analyzer and recorder on standby and record information.	1	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Analytical System (3) Calibration (7) Subpart A,B,C, TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Instrument Calibration (Cont.)	IF ANY ANALYZER REQUIRES A LARGE ZERO AND/OR SPAN READJUSTMENT IN A CALIBRATION, FROM A PREVIOUS CALIBRATION, IMMEDIATELY SUSPECT A POTENTIAL PROBLEM. Calibration gas cylinder pressures must be greater than 100 psig in order to insure validity.	1	5	5
		<u>Carbon Monoxide Analyzer Calibration 1973, 1974, and 1975</u> ° Instrument warm-up (NDIR) ° Adjust analyzer to optimize performance ° Zero the analyzer with zero grade air or nitrogen ° Set the analyzer gain to give desired range on meter ° Calibrate the analyzer with carbon monoxide nitrogen span gases of concentrations: 25,50,70 and 100 percent full scale meter and recorder or computer output* (20,50,70,90) ° Significant analyzer gain change requires maintenance. ° Recheck gain, zero and span data with previous calibration chart/curves ° Place analyzer and recorder on standby, and record information * Federal Register calls for 10, 25, 40, 50, 60, 70, 85, 100 percent points. This is impractical if more than one range is used and a flow blender is not available.	1	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Analytical System (3) Calibration (7) Subpart A,B,C, TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Instrument Calibration (Cont.)	<u>Carbon Dioxide Analyzer Calibration</u>	1-5	5	5
		° Same as CO calibration, using CO_2/N calibration gases			
		<u>Oxide of Nitrogen Analyzer Calibration</u>	1	5	5
		° Instrument warm-up			
		° Adjust analyzer to optimize performance			
		° Zero the analyzer meter and recorder with zero grade nitrogen			
		° Calibrate the analyzer with nitric oxide/nitrogen calibration gases			
		Concentrations of NO/N_2 equal to 50 and 100 percent full scale meter and recorder			
		° Set the NOx analyzer high voltage supply or analyzer gain to match calibration curves/charts	5	5	5
		° 25 and 50 percent gases may be used to determine or verify instrument linearity			
		° Compare with previous curves or computer print-out			

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) Analytical Systems (3) Calibration (7) Subpart B TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Instrument Calibration	Hydrcarbon analyzer (HFID) ° Operate heated analyzer, sample line & filter at 375°±10°F ° Adjust analyzer to optimize performance ° Zero the HFID with zero grade air ° Calibrate the analyzer with propane (air diluent) calibration gas Utilize concentrations equal to 50 and 100 percent of full scale reading. Varify linearity of instrument Analyzer meter reading, Recorder strip chart tract, Or computer output sheet ° Recheck gain, zero, and span data with previous calibration data ° Place analyzer and recorder in standby position record information	1	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) CVS System (3) Theory (8) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	CVS Calibration	Federal Register 38/124, Appendix III, p 17167/8			

1. Warm up the CVS for at least 30 minutes with the blower on to manufacturer's specifications and the heat off.

1. This allows the blower case to reach a stabilized temperature. The calibration is performed at or near room temperature so that minimum LFE correction factors need be applied.

2. Level and zero the micromanometer. An absolute pressure measuring gauge is recommended.

2. A pressure transducer can be used to measure the delta P across the LFE if it is accurately calibrated and read out with a digital voltmeter with sufficient sensitivity to read at least 0.005 inches of water.

3. Connect the LFE with an eight foot length of tape wrapped four inch diameter pipe to either the inlet or the outlet of the CVS.

3. This calibration can be done with either the LFE before or after the CVS. It is recommended that the LFE be used before the CVS blower. This may not be convenient with some CVS designs.

4. Connect a temperature measuring device in the LFE filter inlet. A recommended procedure is to connect a thermocouple mounted in the LFE filter inlet to a temperature recorder.

4. By recording this temperature, one can accurately note when this temperature stabilizes. The exhaust temperature of the LFE may be measured instead of the inlet temperature. However, in this case a longer time at an operating condition is necessary to insure a temperature equilibrium.

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) CVS System (3) Theory (8) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	CVS Calibration (Cont.)				

5. Run lowest speed first if the CVS is to calibrated on all speeds. Usually only high speed of the blower is calibrated and used in testing.

5. The CVS blower adds heat to the air stream and this amount of heat is a function of blower speed and restriction. By running the lowest speed first and increasing the speed one minimizes the temperature change that will occur between successive runs.

6. Start revolution counter (by operating fill switch) and a timer at the same time. RPM should be determined for each data point.

6. A ten minute RPM determination when the system is coming to temperature equilibrium will give a very accurate value.

7. Run a test for 10 minutes or until the LFE inlet temperature stabilizes. (see explanation 4)

7. Temperature stabilization is necessary in order to achieve constant LFE delta P.

8. Read LFE inlet temperature.

9. Read LFE inlet depression

9. This value does not have to be as accurately known as the delta P of the LFE, and therefore can be read with sufficient accuracy at this point.

10. Read LFE delta P to the nearest 0.001 inch of water, if possible.

10. The magnehelic gauges should be calibrated <u>before</u> blower calibration. In all cases the same magnehelic gauge MUST be used for operations that was used for calibration WITHOUT any intermediate changes or adjustments.

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) CVS System (3) Theory (8) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	CVS Calibration (Cont.)				

11. Read CVS inlet temperature.

12. Read CVS inlet delta P.

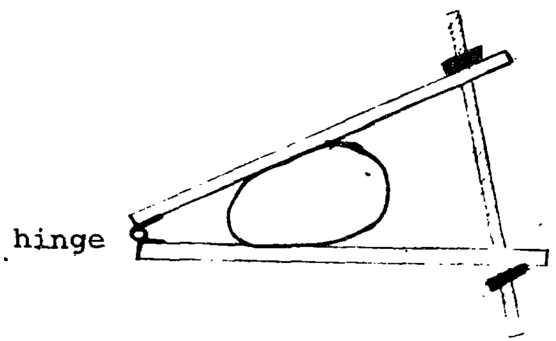
13. Read CVS delta P of the blower.

14. Stop timer and revolution counter.

15. Read revolutions and time.

16. Stop blower, change to next highest speed, repeat steps 5 through 16.

17. Disconnect pipe at CVS pump outlet, add restrictor orifice, reconnect pipe and repeat calibration data of steps 5 through 16.



17. Leak tight connections and temperature equilibrium cannot be over emphasized. If room air handling equipment varies room temperature during the calibration, turn off the air handling equipment and repeat the calibration.
Any type of restriction can be used (instead of orifices) provided that they remain fixed during a test and do not leak.

One technique that has worked is to use a 4 inch diameter silicone rubber boot (about 1 foot long) as a section of the flow path. The boot must be clamped tightly at each end. A large hinged V clamp can then be used to restrict the boot by use of a threaded rod.

MINOR CLASS.	TASK CATEGORY	Task: Light Duty (1) Instrument Technician (4) CVS System (3) Theory (8) Subpart A,B,&C TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	CVS Calibration (Cont.)				

18. Repeat Step 17 with four more orifices until 6 data sets have each speed have been obtained.

19. Complete all calculations on the data sheet.

20. Determine the equation of CFR (cubic foot per revolution) as a function of CVS delta P to the 1/2 power using a least squares fit of the data.

21. Find CFR for each delta P.

18. Other types of restrictors can be used. The orifice size or restrictor that is used should increase the CVS delta P in steps of 2 to 4" of water depending on the design of the CVS.

19. Note that LFE absolute pressure is equal to the barometer minus observed LFE inlet when the LFE is before the CVS blower and the absolute pressure is barometer plus observed LFE inlet when the LFE is used after the CVS blower.

MINOR CLASS.	TASK CATEGORY	Task: Light and Heavy Duty Emissions (1,2) Instrument Technician (4) Analytical System(3) Safety (9) Subpart All TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4, 5	Safety High Pressure Cylinder	° <u>Handle Compressed Gas Cylinders with Care!</u> When energy in a compressed gas cylinder is released suddenly from a broken valve, the cylinder can become a deadly projectile that will smash through a brick wall or zoom airborne for as much as a half-mile, bowling over objects in its path. Workers handling cylinders should be well-trained and work under competent supervision. ° <u>Pressure</u> Internal pressure of some cylinders may reach 2,200 lbs. per sq.inch. Uncontrolled opening of the valve could throw the cylinder to the floor where it would pin-wheel out of control. Or a snapped valve could release "jet power", driving the steel projectile through masonry. ° <u>Heat</u> Keep cylinders out of the sun, away from heat sources. Keep them below 125°F. Store in a dry, well-ventilated place reserved for storage. Store oxygen away from flammable gases and ignition sources. ° <u>Identification</u> You risk serious injury and material damage if you use the wrong gas. <u>Cylinder color does not necessarily identify the gas.</u> Check and recheck the name. (Oxygen and Carbon dioxide are not air). ° <u>Support</u> Store cylinders upright and with safety caps in place. Acetylene should never be stored on its side. Chain or secure cylinders upright in	1-5	5	5

MINOR CLASS.	TASK CATEGORY	Task: Light and Heavy Duty Emissions (1,2) Instrument Technician (4) Analytical System(3) Safety (9) Subpart All TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
		storage, transit and in use. A falling cylinder may damage other equipment or injure persons nearby, even if the valve isn't sheared in falling. Remember, never leave a cylinder standing unsecured. ° <u>Leaks</u> Even slow leaks may be dangerous since some toxic gases are odorless. Most gases can cause asphyxiation by replacing air, and oxygen is a fire hazard. Take "leakers" outdoors. Call the supplier, or if cylinder is considered dangerous, call the fire department as well. ° <u>Transport</u> Move cylinders only on properly equipped trucks. Never drag or roll them across the forks of a "hi-lo". Persons handling cylinders should wear leather gloves and safety shoes. Cradles, not chokers, should be used in transporting from one level to another. ° <u>Use</u> Protect your eyes before connecting up. Install the proper reducing valve or regulator. Open the cylinder valve slowly. If cylinder hand wheel valve sticks, don't use a wrench, but mark the cylinder "stuck valve" and return to the supplier. When gas flow is inadequate, mark "Empty" and recap the cylinder. But treat the cylinder as if filled--some gas remains. Whether full or empty, keep caps on cylinders--straight and snug. Use only the piping or			

MINOR CLASS.	TASK CATEGORY	Task: Light and Heavy Duty Emissions (1,2) Instrument Technician (4) Analytical System(3) Safety (9) Subpart All TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
		pressure tubing designed to withstand the working pressure. Use no oil or grease on valves or fittings (don't handle with oily hands, gloves, etc.). This is critical with oxygen and oxidizing gases. ° <u>Special precautions</u> Before connecting a gas cylinder, refer to the safety data sheet for the gas you plan to use and follow the recommended steps. If a cylinder is damaged or corroded, return it unused to the supplier.			

MINOR CLASS.	TASK CATEGORY	Task: (1,2) 4.3.9 All TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
1,2,4,5,8	Safety Dynamometer	° Exhaust system must be connected to vent when engine is running ° Checks and tie downs should always be used when operating a vehicle on the dynamometer. ° Dynamometer should never be operated outside the limits specified by the manufacturer.	5	1	5
1,2,4,5,8	Safety Fuel	° Fuel must be stored according to the National Fire Protection code and the OSHA. ° Safety cans should be used as auxilliary fuel systems for vehicles or engines where other acceptable means are not available.	5	3	5
1,2,4,5,8	Safety Ambient Air	° All personnel should be aware of the potentially toxicity of exhaust gases, calibration gases and ozone including the maximum allowable exposures limits.			
4,5		° When background concentrations exceed the acceptable limits further vehicle operation and testing should cease and problem identified.	5	3	5

TASK ANALYSIS

B-2 Heavy Duty Engines

THIS TASK ANALYSIS SHOULD NOT BE USED AS A SUBSTITUTE FOR THE FEDERAL REGISTER. IT WAS USED AS A WORKING TOOL TO DEVELOP THE EXAMINATION QUESTIONS, THEREFORE, CORRECTIONS AND OMISSIONS NOTED BY THE PANELISTS IN A REVIEW OF THE TASK ANALYSIS WERE NOT INCLUDED IN THIS DRAFT COPY.

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Dyno Operation (8) Test Procedures (2) Preparation (1) Subparts H,I,J, TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8,5	Engine-Dynamometer Preparation	° Prepare engine test bed to recieve engine	5 or each engine installation	1,3	3,5
		° Lift engine onto stand with hoist and bolt it in place			
		° Bolt coupling to dynamometer and engine shaft; connect fuel and coolant systems using hand tools (refer to appropriate manufacturer's requirements for specifications)		3	5
		° Install inlet air restriction device to provide restrictions of $\pm$ 1" H_2O of upper limits of engine operation which gives maximum air flow			
		° Connect thermocouples and pressure gauges			
		° Check engine for completness, engine mounting, and engine alignment			
		° Determine necessary exhaust system (including muffler) with final results of: 1. Exhaust back pressure to be within $\pm$ 0.2" Hg at maximum rates HP 2. Overall length of exhaust pipe to be 15 feet $\pm$ 5 feet 3. Final two feet of pipe to be straight and round and to size specified for rated BHP (Subpart I)		4	5
		° Fabricate exhaust system and install making provisions for probe location		3	3,5
		° Install intake airflow measuring system and leak check same (Subpart J)			
		° Verify that maintenance procedured have been conplied with		1,3	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Dyno Operation (8) Test Procedures (2) Preparation (1) Subparts H,I,J, TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8,5	Engine-Dynamometer Check out	° Perform visual inspection (leaks, loose hardware etc.) ° Check throttle no-load, full-load positioning ° Check oil and water for proper level ° Check operation of system safety interlocks	5 or each engine installation	3	
		° Start engine and perform visual, audio, and functional inspection Listen for internal noises, such as piston slap, knocks, taps and gear noises that indicate irregularities in engine operation Check for fuel and lubricant leaks Check for exhaust and crankcase emission leaks		1,3	5
		° Bring engine to rated load and speed in gradual steps ° Adjust inlet restriction to within ± 1" H_2O of maximum specified by manufacturer ° Adjust (if necessary) exhaust restriction to ± 0.2" Hg of upper limit specified by manufacturer ° Determine when engine conditions have stabalized and record BHP and fuel rate ° Lug engine to peak torque speed and record torque and fuel rate ° Check engine performance for compliance with manufacturer's specifications, if non-compliance is noted contact supervisor ° Shut down engine and dynamometer systems and record time and ambient temperature ° Fill out request for repairs if necessary ° All pre test functions must be completed in not more than one hour of engine running time		3	5

MINOR CLASS.	TASK CATEGORY	Task· Heavy Duty (2) Engine Dyno Operator (8) Test Procedures (2) Maintenance (5) Subparts H,I,J, TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8,5	Equipment Calibration	PERIODIC CALIBRATION 1. Dyno Torque Readout ° Electronic ° Mechanical 2. Dyno Speed Readout 3. Air Flow Measuring System 4. Fuel Flow Measuring System 5. Temperature & Pressure Measuring Systems 6. All instruments, meters, readouts, or Devices used in measuring or monitoring. **Task: 2.(3,4,5,8) 1.8. All** **Terminology -** *FR - 02 - 03*	1	5	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty Gasoline (2) Engine Dyno Operator (8) Test Procedures (2) Dyno Test (2) Subpart H TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8,5	Engine Dynamometer Operation	<u>DYNAMOMETER TEST RUN</u>			
		1. At end of one hour soak record time and temperature. Verifies that temperature has been between 60°F and 86°F during soak	5	1	5
		2. Start cooling system, if facility cooling system used	5	1	3
		3. Supplies required fuel to engine	5	1	3
		4. Starts engine and idle with no load at 1000-1200 RPM for 5 minutes	5	1	3
		5. Obtains normal idle speed and records it	5	1	3
		6. Runs four 9 mode cycles within speed, time and vacuum limits	5	2	3
		7. Shuts down dynamometer and cooling system and fuel system	5	1	3

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Dyno Operation (8) Durability Testing (5) Dyno Test (2) Subpart I TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8, 5	Durability Test	<u>Accumulation of Durability Hours</u> ° Operate engine at minimum of 95% of rated RPM and maximum rated HP ° Maintain inlet restriction to within ± 3" H_2O of maximum specified by manufacturer ° Maintain exhaust restriction to ± .5" Hg of upper limit specified by manufacturer ° Periodically record RPM, BHP, inlet restriction, and exhaust back pressure ° Add oil and coolant as needed ° Change lube oil, lube oil filter, and fuel filters as specified by manufacturer ° Perform other scheduled maintenance as specified intervals ° Contact immediate supervisor if engine problems develop which require or may require unsceduled maintenance	4	2	5

MINOR CLASS.	TASK CATEGORY	Task; Heayy Duty (2) Dyno Operator (8) Test Procedures (2) Dyno Test (2) Subpart J TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8,5	Systems Operation	Emission Test	5	5	5
		1. Pre-condition engine until temperatures and pressures have stabilized			
		2. Determine maximum torque at rated speed and intermediate speed			
		3. Select peak torque speed or 60% of rated speed whichever is higher			
		4. Calculate torque values for specified test modes	5	3	5
		5. Perform 13 mode emission cycle	5	5	5
		a) Hold engine speed to required tolerance for each mode			
		b) Hold torque to required tolerance for each mode			
		c) Operate engine for required time in each mode			
		d) Maintain temperature of air intake and fuel to required tolerances			
		e) Verify barometric pressure is within limits			
		f) Complete speed and load changes in required time			
		g) Record applicable engine data during last 5 minutes of each mode			

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Dyno Operator (8) Durability (5) Maintenance (3) Subpart J TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8,5	Engine Maintenance	<u>Durability Engines</u> 1. Perform major engine servicing to manufacturer's specs at 500 hours. Servicing restricted to the following a) Adjust low idle speed b) Adjust valve lash if required c) Adjust injector timing d) Adjust governor e) Clean and service injector tips	1	5	5
		2. Conditional maintenance as follows a) Change injectors <u>if</u> persistent misfire is detected b) Adjustment of engine fuel rates <u>if</u> 95% of maximum rated horse power cannot be maintained c) Leaks in fuel system, lubrication system, and cooling system as required	as req'd	3	5
		3. Normal engine lubrication services a) Drive belt tensions and engine b) Bolt torque at manufacturer's recommended intervals	as req'd	1	5
		4. Engine low idle speed at 125 hour test point	as req'd	3	3
		<u>Emission Data Engines</u> 1. Adjust engine low idle speed at 125 hour test point	as req'd	3	3
		2. Normal engine lubrication services as required at manufacturer's recommended intervals	as req'd	1	3

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty Diesel (2) Dyno Operator (8) Durability (5) Dyno Test (2) Subpart J TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8,5	System Operation	<u>Engine Hour Accumulation</u> ° Adjust and maintain system at correct percentage of rated speed ° Adjust and maintain system at correct percentage of maximum rated horse power ° Monitor system parameters on an as required basis ° Record pertinent system information on a chronological basis	as req'd	3	5
		<u>Hour Accumulation Record</u> ° All maintenance performed on engine ° Number of running hours ° Record the following engine information as required: a) Speed b) Horsepower c) Exhaust back pressure d) Pertinent temperatures and pressures e) Airflow f) Fuel flow g) Any other information desired	as req'd	1	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Instrument Tech (4) Analytical Systems (3) Calibration (7) Subparts H, J. TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Primary Calibration	General Requirements			
		° Verify instrument compatability with manufacturer's specifications (functional checkout)	1	5	5
		° Leak check instrument	1	5	5
		° Set up flow rates and operating temperatures	1	5	5
		° Insure that instruments are warmed up sufficiently prior to start of curve generation	1	5	5
		° Zero on nitrogen or air	1	1	3,5
		° Calibration of all readout devices			
		° Tune analyzers			
		° Verify that calibration gases are of appropriate concentrations accuracies and compositions	1	5	5
		° Generate calibration data for instruments using prescribed standards	1	5	3,5
		° Compare values with previous curves, if significant change has occurred locate and correct problem	1	3	3,5
		° Use best judgement in selecting curve for data reduction	1	5	5
4,5	Primary Calibration and Maintenance	NO, CO, CO_2 Requirements NDIR	1	5	5
		° Generate calibration curve for instrument using primary standards			
		° Check instrument for interference susceptibility			
		° Consider effects of indicating dri-rite on calibration and sample results			
		HC - NDIR Subpart H only	1	5	3
		° Check response of hydrocarbon analyzer to 100% CO_2 and water vapor			
		° Refill filter cell if necessary			

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Instrument Technician (4) System (3) Preparation (1) Subpart H, J, TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Pre-test System Preparation	° Verify appropriate zero, span, fuel, burner air gases of appropiate concentrations and quantities are at hand	5	5	5
		° Warm up instrumentation			
		° Check sample probes and lines and clean/replace as required			
		° Verify appropriate probe length and location			
		° Leak check entire sample system (before and after test)			
		° Clean/replace filter/filter elements as necassary			
		° Drain water from sample line traps in refrigerated bath	5	5	3
		° Install driers and condition as required	5	5	5
		° Load recorder and verify functional operation			
		° Verify operating system temperature and temperature stability			
		° Complete functional check out of instrumentation system			
		° Adjust zero gas flow rate and zero analyzer and readout device	5	1,5	3,5
		° Adjust span gas flow rate, span analyzer and readout device (use calibration curve if req'd)	5	3,5	5
		° If gain has changed by more than 3% locate and correct problem			
		° Adjust air fuel, sample flow rates as applicable	5	5	5
		° Recheck zero and span an check agreement between primary output device (computer) and strip chart recorder	5	3	3

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Instrument Technician (4) Analytical Systems (3) Preconditioning (1) Subpart J TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Primary Calibration and Maintenance	<u>FID REQUIREMENTS</u> 1. Verify that fuel and air compositions are as required. 2. Establish fuel, air and sample pressures/flows required for operation. 3. Establish Operating temperature for system. 4. Determine Oxygen response of system and generate calibration curve if required. 5. Determine linearity of instrument and prepare calibration curve if required 6. Check system for hydrocarbon hangup. 7. Verify operation of equipment safety interlocks.	1 Or as req'd which-ever comes first	5	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Instrument Technician (4) Test Procedures (2) Dyno Test (2) Subpart H TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Analytical System Sample Handling	Dynamometer Test Run			
		° Start exhaust sampling after normal idle speed has been obtained	5	1	3
		° Continuously monitor exhaust gas concentrations during all four 9-mode cycles	5	1	3
		° Purge low hydrocarbon if necessary during closed throttle decel mode	5	1	3
		° On recorder charts identify zero, span, and modes	5	1	5
		° Record a) Barometric pressure, intake air temperature, humidity, and air temperature in front of radiator (if used) b) A continuous trace of intake manifold vacuum and engine RPM with an automatic mark every second on the chart c) Brake horse power for each mode d) Fuel consumption for each mode	5	5	5
		° After run purge sample line with N_2 and determine HC hangup, should drop to 5% in 10 seconds and 3% in 3 minutes	5	3	3
		° Check zero and span to determine drift, should be less than 2% of full scale	5	3	3
		° Record the following information a) Test number b) System tested (brief description) c) Date and time of day for each part of the test schedule d) Instrument operator e) Dyno operator f) Engine make-identification number-date of manufacture-number of hours-engine displacement-engine-idle RPM-number of carburetors-number of carburetor venturis g) All pertinent instrument information such as tune, gain, serial number, detector numbers, and range	5	1	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty Diesel (2) Instrument Technician (4) Test Procedures (2) Dyno Test (2) Subpart J TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Test Operations	<u>Emission Tests</u> 1. Record response of analyzers on strip chart recorders with exhaust gas flowing through analyzer for at least 5 minutes of each mode 2. Check flow rates/pressure and temperatures throughout test 3. Check and reset zero and span setting of analyzers as required-repeat mode(s) depending on repeat-ability of these 4. Back flush condensate trap 5. Change filters, driers as necessary 6. Select appropriate range/cell length for each mode and zero & span required 7. Adjust purge flow as required 8. Drain condensate traps as required	5	5	5
Analytical Instrumentation	Record Keeping	<u>Equipment</u> 1. Maintenance logs on all pieces of major equipment <u>Test Data</u> 1. Record data as specified in Federal Register Paragraph 85.974-14 2. Record other data as desired	as req'd	3	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Instrument Tech (4) Analytical Systems (3) Preparation (1) Subpart I TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Set Up and Check of Smokemeter and Recorder	<u>Smokemeter and Recorder Setup</u> ° Move proper equipment into test cell ° Make all necessary electrical connections to record smoke opacity, engine speed, and engine torque ° Hook up air supply to smoke head and adjust: 1. Optical centerline 5 ± 1" from pipe outlet 2. Optical centerline at right angles to exhaust plume ° Turn on power to control unit of smokemeter and allow minimum of 15 minutes for stabalization ° Turn on power to recorder and allow sufficient time for specified warm up ° Clean lenses in smoke head if necessary ° Turn on purge air to smoke head ° Turn on chart recorder after checking paper supply and inking pens operation	5	3	5
4,5	Calibration	<u>Task: 2,4,3,7,I</u> ° Set zero and 100% opacity on smoke channel resolution to be within 1% opacity ° Insert neutral density filters (nominal 10,20,& 40%) in light path on smokemeter (same side as light source) Verify that recorded values on the chart are within 1% of the filter value as determined by EPA ° Calibrate RPM channel to show linearity and to give a resolution within 30 RPM ° Calibrate torque channel to show linearity and to give a resolution within 10 FT.LBS. ° Contact instrument repairman and/or supervisor if desired calibration is not possible			

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Engine Operator (8) Test Procedures (2) Dyno Test (2) Subpart I TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8, 5	Test Performance	Smoke Emissions Test ° Run engine to determine by experimentation the inertia and dynamometer load required to perform the acceleration phases of the smoke emission cycle ° Check operation of engine throttle control to insure conformance with acceleration phases of smoke test ° Bring engine to rated speed and load. Adjust inlet and exhaust restrictions (if required). Record the following: BHP Fuel rate Inlet restriction Exhaust back pressure Ambient air temperature Intake air temperature (within 68° to 86°) Humidity and barometric pressure ° Lug engine to peak torque speed, record fuel rates and torque ° Remove all dyno load and allow engine to run at maximum governed RPM. Record that RPM ° Reduce speed to low idle ° Set zero and 100% on the smokemeter recorder with smoke head away from smoke plume. Insert neutral density filters (nominal 10,20,&40%) The recorded values must fall within ± 1% of EPA established values ° Recheck calibration of speed and torque for preconditioning ° Remove all dyno load and bring engine to low idle. This represents start of first smoke cycle	5	4	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Engine Operator (8) Test Procedures (2) Dyno Test (2) Subpart I TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8, 5 (Cont.)	Test Performance (Cont.)	<u>Smoke Emissions Test (Cont.)</u> ° Operate engine at low idle for 5 to 5.5 minutes ° Center smoke head over exhaust plume during low idle ° Increase recorder chart speed to a minimum of 8" per minute at end of low idle period ° Increase engine speed to 200 ± 50 RPM above low idle within 3 seconds ° Accelerate engine at full throttle against dynamometer load selected earlier so that engine speed reaches 85 to 90% fo rated speed within 5.0 ± 1.5 seconds. Acceleration to be linear within ± 100 RPM ° Move throttle rapidly to closed position and apply preselected load ° Observe RPM drop. Apply full throttle when engine speed reaches 60% of rated speed or peak torque speed (whichever is higher) within ± 50 RPM ° Allow engine to accelerate for 10 ± 2 seconds during which the engine speed must reach 95% of rated RPM ° Stabilize engine at maximum rated HP under full throttle ° Increase dyno load to lug engine to peak torque speed or 60% rated RPM (whichever is higher) within 35 ± 5 seconds. Lug phase to be linear within ± 100 RPM ° Remove dyno load and reduce speed to low idle (Completion Of One Test Cycle)	5	4	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Engine Operator (8) Test Procedures (2) Dyno Test (2) Subpart I TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
8,5 (Cont.)	Test Performance (Cont.)	<u>Smoke Emissions Test (Cont.)</u> ° Run two additional test cycles ° Shut engine down ° Check smokemeter calibration Repeat test if zero drift is greater than 2% Reset zero if drift is less than 2% Check 100% and insert neutral density filters Repeat test is recorded values deviate by more than 2% of actual values	5	4	4

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Data Analyst (3) Data Reduction (4) Calculations (4) Subpart H TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
3,5	Chart Reading	<u>Reduction of Exhaust Emission Test Data</u>			
		° Determine whether the cycle was run in accordance with ths specified cycle timing and vacuum tolerances	5	1	3
		° Time correlate the hydrocarbon, carbon monoxide, nitric oxide, and carbon dioxide charts	5	3	3
		° Determine the location on the chart of concentrations corresponding to each mode	5	3	3
		° Determine and compensate for trace abnormalities	5	5	5
		° For all open throttle and idle modes intergrate the last 3 seconds on the NO, HC, CO, and CO_2 traces	5	3	3
		° Intergrate the complete NO, HC, CO, and CO_2 traces during this 43 second closed throttle mode of each cycle	5	3	3
		° Check computer analysis for correct data input	5	3	3
		° Correlate computer with hand calculations to assure validity of results	1	5	3
		° Confirm that all necessary information has been recorded	5	3	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Data Analyst (3) Data Reduction (4) Calculations (4) Subpart I TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
3, 5	Data Reduction	<u>Chart Reading</u> ° Locate the acceleration and lugging modes on the chart Divide each mode into one-half second intervals Determine the average smoke reading during each one-half second interval, omitting those recorded during the transitional periods ° Record the 15 highest one-half second readings during the acceleration modes for each of the three cycles Determine the average of the 45 readings within the acceleration modes. Record this average as value "a" ° Record the 5 highest one-half second readings during the lug mode for each of the three cycles. Determine the average of the 15 readings within the lug modes. Record the average as value "b" ° Record the 3 highest readings from each cycle (readings may be from either mode or both) Determine the average of the 9 readings. Record this average as value "c"	5	3	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty (2) Data Analyst (3) Durability Testing (5) Calculations (4) Subpart I TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
3,5	Data Reduction	<u>Calculation of Deterioration Factors</u> ° Establish emissions deterioration factors for acceleration mode ("A"), lugging mode ("B"), and peak opacity ("C") from 1000 hr durability data ° Plot all applicable data as a function of hours on the system Draw best fit straight line, using method of least squares, through data points Verify that the interpolated 125 hr and 1000 hr points are within standard prior to calculating deterioration factor ° Calculate deterioration factors: "A" % opacity "a" interpolated to 1000 hrs minus % opacity "a" interpolated to 125 hrs "B" % opacity "b" interpolated to 1000 hrs minus % opacity "b" interpolated to 125 hrs "C" % opacity "c" interpolated to 1000 hrs minus % opacity "c" interpolated to 125 hrs ° Combine opacity values "a","b","c" and deteriation values "A","B","C" respectively. Results obtained are the percent opacity values to be compared with the standard	5	4	5

MINOR CLASS.	TASK CATEGORY	Task: Heavy Duty Diesel (2) Data Analyst (3) Data Reduction (4) Calculations (4) Subpart J TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4,5	Data Review	1. Review all test data for completeness, reasonableness	5	5	5
	Calculations	1. Calculate Pollution Concentrations a) Determine average chart reading for each pollutant for each mode utilizing last 60 seconds of each mode b) Determine concentration of each pollutant from average chart reading and corresponding instrument scale factors and calibration data c) Calculate brake specific emissions for each pollutant for each set of data	5	5	5
		2. Calculate Deterioration Factors a) Establish separate deterioration factors for CO and for combined HC and NOx b) Plot applicable results as a function of engine hours c) Use best least squares fit through data points d) Compare 125 and 1000 hr points to allow standards to determine data acceptability e) Calculate deterioration factor	as req'd	5	5
		3. Application of Deterioration Factors to Emission Engines a) Add to emission engine test results b) Compare results to emission standards	as req'd	5	5
	Record Keeping	1. Identification and description of all engines tested 2. Description of all emission control systems installed or incorporated in each engine 3. Test data on each durability and emission data engine 4. Summary of all pertinent data and calculation results			

MINOR CLASS.	TASK CATEGORY	Task: Light and Heavy Duty Emissions (1,2) Instrument Technician (4) Analytical System(3) Safety (9) Subpart All TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
4, 5	Safety High Pressure Cylinder	° <u>Handle Compressed Gas Cylinders with Care!</u> When energy in a compressed gas cylinder is released suddenly from a broken valve, the cylinder can become a deadly projectile that will smash through a brick wall or zoom airborne for as much as a half-mile, bowling over objects in its path. Workers handling cylinders should be well-trained and work under competent supervision. ° <u>Pressure</u> Internal pressure of some cylinders may reach 2,200 lbs. per sq.inch. Uncontrolled opening of the valve could throw the cylinder to the floor where it would pin-wheel out of control. Or a snapped valve could release "jet power", driving the steel projectile through masonry. ° <u>Heat</u> Keep cylinders out of the sun, away from heat sources. Keep them below 125°F. Store in a dry, well-ventilated place reserved for storage. Store oxygen away from flammable gases and ignition sources. ° <u>Identification</u> You risk serious injury and material damage if you use the wrong gas. <u>Cylinder color does not necessarily identify the gas.</u> Check and recheck the name. (Oxygen and Carbon dioxide are not air). ° <u>Support</u> Store cylinders upright and with safety caps in place. Acetylene should never be stored on its side. Chain or secure cylinders upright in	1-5	5	5

storage, transit and in use. A falling cylinder may damage other equipment or injure persons nearby, even if the valve isn't sheared in falling. Remember, never leave a cylinder standing unsecured.

- Leaks
  Even slow leaks may be dangerous since some toxic gases are odorless. Most gases can cause asphyxiation by replacing air, and oxygen is a fire hazard. Take "leakers" outdoors. Call the supplier, or if cylinder is considered dangerous, call the fire department as well.

- Transport
  Move cylinders only on properly equipped trucks. Never drag or roll them across the forks of a "hi-lo". Persons handling cylinders should wear leather gloves and safety shoes.

  Cradles, not chokers, should be used in transporting from one level to another.

- Use
  Protect your eyes before connecting up. Install the proper reducing valve or regulator. Open the cylinder valve slowly. If cylinder hand wheel valve sticks, don't use a wrench, but mark the cylinder "stuck valve" and return to the supplier.

  When gas flow is inadequate, mark "Empty" and recap the cylinder. But treat the cylinder as if filled--some gas remains.

  Whether full or empty, keep caps on cylinders--straight and snug. Use only the piping or

MINOR CLASS.	TASK CATEGORY	Task: Light and Heavy Duty Emissions (1,2) Instrument Technician (4) Analytical System(3) Safety (9) Subpart All TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
		pressure tubing designed to withstand the working pressure. Use no oil or grease on valves or fittings (don't handle with oily hands, gloves, etc.). This is critical with oxygen and oxidizing gases. <u>Special precautions</u> Before connecting a gas cylinder, refer to the safety data sheet for the gas you plan to use and follow the recommended steps. If a cylinder is damaged or corroded, return it unused to the supplier.			

MINOR CLASS.	TASK CATEGORY	Task: (1,2) 4.3.9 All TASK ANALYSIS	FREQUENCY	SKILL	IMPORTANCE
1,2,4,5,8	Safety Dynamometer	° Exhaust system must be connected to vent when engine is running ° Checks and tie downs should always be used when operating a vehicle on the dynamometer. ° Dynamometer should never be operated outside the limits specified by the manufacturer.	5	1	5
1,2,4,5,8	Safety Fuel	° Fuel must be stored according to the National Fire Protection code and the OSHA. ° Safety cans should be used as auxilliary fuel systems for vehicles or engines where other acceptable means are not available.	5	3	5
1,2,4,5,8	Safety Ambient Air	° All personnel should be aware of the potentially toxicity of exhaust gases, calibration gases and ozone including the maximum allowable exposures limits.			
4,5		° When background concentrations exceed the acceptable limits further vehicle operation and testing should cease and problem identified.	5	3	5

APPENDIX C

PREPARATION OF TEST QUESTIONS

SEMINAR II HANDOUT

APPENDIX C
PREPARATION OF TEST QUESTIONS

The examination for the certification of emission laboratory technicians will be an objective test. Three categories of objective questions (Items) have been chosen for the construction of the examination, they are:

1. Alternate - Response Item
2. Multiple Choice Item
3. Matching Exercises

Some general suggestions for constructing objective Items are:

1. Rules governing good language expression should be observed to avoid misinterpretation.
2. Difficult words which are not directly related to the technical content should be avoided.
3. Textbook (Federal Register) wording should be avoided.
4. Ambiguities should be avoided.
5. Items having obvious answers should not be used.
6. Clues and suggestions should be avoided.
7. Items that can be answered by intelligence alone should not be included. (i.e., not related to job training or experience.)
8. Quantitative rather than qualitative words should be used.
9. Catch words should not be employed.

PREPARATION OF TEST QUESTIONS

CATEGORY I

ALTERNATE-RESPONSE ITEMS:

Alternate-response items are those in which only two alternatives are presented to the pupil for his response. The simplest and most common forms of alternate-response items are the true-false and the yes-no, requiring one of those answers to a question.

The true-false, as the most widely used alternate-response type has doubtless been the most popular form of recognition items and probably remains so today for classroom testing purposes. It typically involved a very simple method of response by the pupil in aligned answer positions at either the left or right side of the test paper.

Uses and limitations of alternate-response items:

The true-false item is widely applicable in all subject fields. Its ease of construction has resulted in greater popularity and wider use than have been attained by any other item form. However, its ease of construction is frequently delusive, for the elimination of ambiguities from the true-false item is sometimes difficult to accomplish.

Alternate-response item forms have the advantage of affording coverage of many individual items in a short period of time, since the time requirements are less than for most item types. On the other hand, guessing is more of a problem for this than for any other item type, for which reason little diagnostic value can be obtained by using an item-count method of analyzing the results for groups of pupils or an individual pupil. Alternate-response response items are highly objective in scoring, and are readily understood by pupils. This item type is readily scorable by mechanical methods in all of its common varieties.

True-false items can be used satisfactorily in many situations if they are constructed carefully enough to keep them free from ambiguity. They are especially useful for situations in which the absence of enough plausible alternative-responses makes the use of multiple-choice item impracticable.

Major types of alternate-response items:

The most common form of true-false item may be set up so that the pupil will respond by encircling or underlining a T or F, or a True or False. The arrangement of answer spaces in columns under T and F in which the answer is indicated by an "X" or check mark has the added advantages of speed of response and ease of scoring.

Suggestions for Constructing Alternate-Response Items:

The suggestions below for the alternate-response type of item supplement the general suggestions previously discussed. As the true-false is the most widely used of these types, most of the suggestions below relate primarily to it or a closely allied form.

1) Double negative statements should be avoided.

Double negatives serve no useful purpose, but they may cause needless and harmful reading problems for some pupils.

2) Statements that are part true and part false should not be used.

Statements should be either true or false, for the use of a true major clause and a false dependent clause or of some other combination of truth and falsity is confusing to the pupil and adds nothing to the test. Although such part true, part false statements are used by some test workers, the result frequently is an unintentional "catch" item.

3) "Specific determiners" should be used sparingly and carefully.

Such specific determiners are "always" and "never" occur in false statements much more frequently than in true statements. Statements containing cause or reason clauses also tend to be false more often than true. On the other hand, comparison statements and very long statements are more often true than false.

4) <u>Answers should be required in a highly objective form</u>.

It is inadvisable to have pupils write a letter, such as T or F, or a word, such as True or False, in answering the items, for those letters and words look much alike when poorly written or when written with the attempt to confuse the scorer. Methods requiring examiners to encircle or to underline T or F, Yes or No, having pupils mark an "X" in the brackets in either T or F column are to be preferred.

PREPARATION OF TEST QUESTIONS

CATEGORY 2

MULTIPLE-CHOICE ITEMS:

Multiple-choice items have come to be the most popular form for standardized testing of recent years, and are increasingly coming into wide use for informal objective testing as well. A recognition item type, the multiple-choice item commonly consists of an incomplete statement followed by from three to five responses that will complete the statement with varying degrees of accuracy. The pupil is expected to choose the response that correctly or best completes the statement, and typically to indicate his choice by an answer appearing in a column at the left or the right side of the test paper.

This item type may be in question rather than in statement form or may consist of three to five words, symbols, or numbers from which the correct one is to be chosen by the pupil. It may request the best of several correct or partially-correct answers on a given point. It may even require responses for the two or more correct answers among those furnished, in which case it becomes a multiple-response item.

Uses and limitations of multiple-choice items:

The multiple-choice and its numerous variants perhaps represent the most valuable and at the same time the most widely applicable type of objective test item. It is readily, although not necessarily easily, adaptable to the measurement of discriminative power, inferential reasoning, interpretive ability, reasoned understanding, generalizing ability, and other types of outcomes deriving from the pupil's ability to apply and use facts. It is not difficult for pupils to understand and use. It is highly objective, and can be readily scored either by hand or by machine. Item-counting procedures based on the results for an individual pupil or a class have considerable diagnostic and analytic significance.

Multiple-choice and multiple-response items in their variety of forms are so widely adaptable to different types of content that the preceding discussion should make the fact evident without illustration. As is the case for the true-false item, there is probably no field of learning to which the multiple-choice item is not widely applicable. However, the necessity for finding at least two and in many cases as many as four plausible responses to go with the correct completion somewhat limits the applicability of the item form within each subject field. Ingenuity on the part of the test maker and the results of practice in item construction make the item type very widely applicable to the content of various instructional areas, however. Multiple-choice items are not as easily constructed as are some other objective test forms, for there are various technical problems that require great care in the drafting of items. The incorrect answers pupils give to simple recall items often serve as excellent incorrect alternatives if the item is converted to multiple-choice form.

Major Types of multiple-choice Items:

The basic and probably most common multiple-choice form is that in which the correct or best completion is to be selected by the pupil from the three to five that are furnished for an incomplete declarative sentence or in answer to a question.

A common use of multiple-choice forms is in testing various types of reading ability, as, for example, ability to comprehend the meaning of a paragraph, by basing a single item or several items on a passage of reading material in English or a foreign language. Somewhat similarily, multiple-choice items can singly or by groups be based on a map, chart, diagram, or table, and require the pupil to interpret the date presented as a basis for answering.

Suggestions for Constructing Multiple-Choice Items:

The following suggestions, are primarily for the multiple-choice item type with only one correct answer or the closely related best-answer type.

1) As much of the statement as possible should occur in the introductory portion or stem. There is no justification for repetition of the same introductory word or words in each of the alternatives; the introductory, or common, portion of the item should include as much as possible as a means of saving space.

2) <u>Alternative answers should all be stated in correct grammatical style</u>. It should be possible to follow the stem of an item with any one of the alternative answers and have the statement be grammatically correct.

3) <u>Incorrect alternatives, or confusions, should be plausible</u>. One or more alternatives that are obviously incorrect in effect give the pupil a greater chance of guessing the correct answer. Pupils' wrong answers to recall items often provide excellent confusions for the same items if put into multiple-choice form.

4) <u>"A" or "an" should not ordinarily be used to introduce the alternative answers</u>. Unless all answers can follow the same article with grammatical correctness, the "a(n)" device mentioned above or the indefinite article should be used to introduce the alternative answers.

5) <u>Items should ordinarily have four or five alternative answers</u>. Except for use with very young children, four or five alternative answers are preferable as a means of reducing the chances of guessing the correct answer and in order to obtain the desired degree of item difficulty, although two well-chosen confusions are preferable to three or four implausible wrong answers.

6) <u>All items should ordinarily have the same number of alternate answers</u>. Four- and five-response items should ordinarily not be mixed in the same test, for the same number of alternatives for each item is preferable for ease in correction for guessing.

7) Alternative answers should ordinarily occur at the end of the statement. Although the responses may be so placed that additional material common to all is necessary to complete the statement, rewording will ordinarily make possible their placement at the conclusion of the statement.

8) Answers should be required in a highly objective form. It is perhaps preferable that a pupil write the identifying letter or number for the intended response or encircle or otherwise mark it in a special answer column. There is little efficiency in a method requiring underlining or, worse yet, both underlining and otherwise indicating, an intended answer.

PREPARATION OF TEST QUESTIONS

CATEGORY 3

MATCHING EXERCISES:

Matching exercises are in effect combinations of multiple-choice items in such a manner that the choices are compound in number. Matching exercises differ from all of the objective forms treated previously in the fact that they must occur in groups. There is really no such thing as a matching test item, unless a correct pairing pulled from a group of which it is a part might be so designated. Matching tests are by nature, then, multiple in type, and the number of scoring points is ordinarily determined by the number of responses required of the pupil.

A matching exercise or set usually consists of two lists of related facts between which a constant type of relationship exists throughout. The pupil's responses are expected so to pair items in the two lists as to indicate their proper relationships. Variations involve unbalanced sets, in which more items occur on one side than on the other, sets in which items of one side may be used more than once each, and even compound sets in which double or even triple matchings of all items are necessitated by the provision of three or even four related lists instead of the customary two.

Pupil responses to matching exercises are usually in the form of identifying numbers or letters written in column form in parallel with the items in one of the two or more lists. The unbalanced set has the definite advantage of reducing the chances of guessing the correct answers to practically zero.

Uses and limitations of matching exercises. Matching exercises are likely to be rather highly factual in nature, and to make use of the who, what, when and where types of relationships and of identifying or naming abilities. They are rather easy to construct, and are perhaps for that reason more widely used than their characteristics warrant. They are likely to include clues to the correct responses unless there is rigid adherence to uniform categories of items in a matching set, and this restriction, desirable though it is, limits at least one side of the test unit to numbers, words, or at least short phrases. This restriction in turn tends to limit use of the item form mainly to factual types of subject matter.

The matching exercise is economical of space and of construction time. It is useful for matching terms and definitions, names and events, events and dates, books and authors, causes and effects, generalizations and applications, words and symbols, English and foreign words, and many other pairs of related items by use of verbal lists. It is also useful with numbered maps, charts, or pictorial representations for matching places and names, places and events, trends and dates, or objects and names in great variety. The matching exercise appears to be most useful with factual knowledges in a great variety of situations where it is desirable to test over a number of comparable relationships.

Major types of matching exercises. The fundamental form of matching exercise has an equal number of items in both lists and involves the use of all of the items in the pairing. Unbalanced matching sets provide more items on one than on the other side and require that only as many of the items of the longer list be used as have proper pairing with the items of the shorter list.

Suggestions for Constructing Matching Exercises:

1) Only one correct matching for each item should be possible. If items are not mutually exclusive, i. e., subject to only one correct matching, some pupils may be penalized because they happen to choose the one or two or more possible matchings for a certain item that results in the lack of a proper answer for an item at the end of the matching process, when the same number of items appears in each column.

2) Consistency of grammatical form should be used. All items in the left-hand set should agree in form and all items in the right-hand set should like wise be in agreement. It should be possible insofar as the form of the statements is concerned, to associate any item of the left with any item of the right column. If this is not true, answers can be obtained partly by attention of the pupil to grammatical detail in the statements.

3) Consistency of classifications should be maintained. Each of the two lists should contain items that are of the same category. Although matching sets that are not consistent within each column are used by some test makers, the results from mixed

categories are sometimes confusing, often provide a means of answering items by the exercise of general intelligence alone, and in general are unsatisfactory. Consistent categories are much to be perferred.

4) Matching sets should neither be too long nor too short. From ten to fifteen parings are probably optimum for balanced-matching groups. More than fifteen pairs become cumbersome and time-consuming. Fewer than ten pairings present opportunities for good guessing on the last few matchings by the pupil who knows most of the pairings. Unbalanced matchings sets are definitely preferable and perhaps should be used in all matching sets.

5) Items should be listed in random order in each list. Such logical arrangements as alphabetical order of first letters of words and chronological order of dates usually accomplish this purpose, for such arrangements are not likely to have any similarity to the relationships between the items of the two lists and furnish no clues to the pupils.

6) A set of matching items should always be complete on one page. The necessity for frequent rereading of items makes very inefficient any separation of a set of matching items by having it appear on two pages of the test.

7) Answers should be required in a highly objective form. Perhaps the most satisfactory method of providing for pupil responses is to accompany one list with letters or numbers identifying each item and the other list by answer positions, and then to have pupils write

the letters or numbers in the answer column in such manner as to indicate their choices.

APPENDIX D

SAMPLE OF TEST QUESTIONS

D-1 Alternate Response Questions

D-2 Multiple Choice Questions

D-3 Matching Questions

SAMPLE OF TEST QUESTIONS

D-1 Alternate Response Questions

APPENDIX D-1

SAMPLES OF ALTERNATE RESPONSE (TRUE-FALSE) QUESTIONS

2 3 2 2 H *

401. The deviation in vacuum level allowed for the heavy duty procedure during the PTD and cruise modes is 0.3 inches of mercury. T F 401

402. The deviation in vacuum level allowed for the heavy duty procedures during the PTA and FL modes are 0.2 inches of mercury. T F 402

403. During the heavy duty gasoline engine test the closed throttle modes are allowed to deviate from the specified time by two seconds. T F 403

2 3 4 4 H

404. A CO_2 reading of 5% during a 16 inches of mercury vacuum mode indicates that the engine is running as it should. T F 404

405. You should question the accuracy of the reading if the NO concentration doesn't change between the idle mode and the 16 inches of mercury vacuum mode. T F 405

2 3 4 4 I

417. The smoke recorded during the acceleration from low idle to 200 ± 50 rpm above low idle is not part of the calculated "a" value. T F 417

418. Smoke recorded during the transitional periods is not used to calculate smoke values. T F 418

419. Zero hours smoke values are included in the calculation of deterioration factors. T F 419

420. The acceleration mode is divided into one-second intervals on the smoke-recorder chart. T F 420

421. The lugging mode is divided into 15 equal segments on the smoke-recorder chart. T F 421

422. The 15 highest readings from each acceleration mode are used in calculating value "a". T F 422

* Refer to Table 4-1 for Data Bank Code

Answers: 401 - T, 402 - T, 403 - T, 404 - F,

405 - T, 417 - F, 418 - T, 419 - F,

420 - F, 421 - F, 422 - T

SAMPLE OF TEST QUESTIONS

D-2 Multiple Choice Questions

APPENDIX D-2

SAMPLES OF MULTIPLE CHOICE QUESTIONS

1 1 2 1 A C

26. During preconditioning of the dyno, the driving aid recorder should be checked for:

    a. Span and zero.

    b. Ink.

    c. Chart paper.

    d. All of the above. . . . . ( ) 26

27. During the evaporative preconditioning, a vehicle is operated on an approved route for:

    a. 15 minutes.

    b. 30 minutes.

    c. 45 minutes.

    d. 60 minutes.

    e. 90 minutes. . . . . ( ) 27

1 2 2 2 A B C

152. The driver's aid is started:

    a. When cranking begins.

    b. When the engine starts.

    c. 15 seconds after engine starts.

    d. When first accel begins. . . . . ( ) 152

1 3 1 4 A

214. The temperature used to calculate bag mass emissions of a vehicle is:

a. CVS inlet temp.

b. Car exhaust temp.

c. CVS pump inlet temp.

d. Ambient temp.

e. Bag temp. . . . . ( ) 214

1 4 2 3 A B C

332. Start CVS revolution counter, timer and sample collection:

a. At start of cranking.

b. When the engine starts.

c. When driving schedule is started.

d. 5 sec. before cranking starts. . . . . ( ) 332

1 4 3 3 A

333. The charcoal filter in the CVS dilution air stream:

a. Removes CO.

b. Removes HC.

c. Stabilizes CO.

d. Stabilizes HC.

e. None of the above. . . . . ( ) 333

2 3 2 1 J

435. The recommended barometric pressure limits for diesel emission testing are:

a. 28.90 to 29.50 inch mercury.

b. 28.00 to 30.50 inch mercury.

c. 28.50 to 31.00 inch mercury.

d. 29.00 to 31.00 inch mercury. . . . . ( ) 435

2 4 2 6 H J

520. You are observing a strip chart recording of CO at a steady state of 30 chart divisions. It suddenly starts decreasing until it reaches about 5 to 10 units of chart. Which of the following could be the cause?

a. Chopper motor has stopped.

b. Analyzer gain was set too high.

c. A leak in the sample line or filter.

d. Analyzer was spanned incorrectly. . . . . . . ( ) 520

2 4 3 5 H

521. When the indicating desiccant (drierite) changes color, it means that:

a. The system is warm enough to use.

b. The span gas is contaminated.

c. It can be used for two more tests.

d. The desiccant should be changed.

e. The system needs calibration. . . . . ( ) 521

2 4 3 6 H

522. If the HC-NDIR analyzer response to wet N_2 is greater than 5% of full scale, the problem is most likely in the:

a. Calibration.

b. Chopper motor.

c. Detector.

d. Sample flow rate. . . . . ( ) 522

2 8 2 2 I

650. Intake air restriction must be set at:

a. Rated speed and rated load.

b. High idle.

c. Rated torque peak speed and rated load.

d. The conditions of maximum air flow as established by the manufacturer. . . . ( ) 650

651. The dynamometer test run for a smoke emissions test consists of:

a. 2 smoke cycles.

b. 1 smoke cycle if data looks good.

c. 3 smoke cycles.

d. 3 smoke cycles plus a torque curve. . . . ( ) 651

652. What is the accepted method of selecting dynamometer loads for the acceleration modes of the smoke cycle.

a. Load is dependent on dyno inertia.

b. Determined by experimentation.

c. Calculate loads from specified torque.

d. All of the above.

e. None of the above. . . . . ( ) 652

Answers: 26 - d, 27 - d, 152 - b, 214 - c, 332 - a, 333 - d, 435 - c, 520 - c, 521 - d, 522 - c.

SAMPLE OF TEST QUESTIONS

D-3 Matching Questions

APPENDIX D-3

SAMPLES OF MATCHING QUESTIONS

1 1 2 1 A C

Match the appropriate ambient temperature range in column 1 with the portion of the evaporative emissions test for light duty vehicles described in Column 2. Items from Column 1 may be used more than once.

Column 1		Column 2		
a. 76° - 86°F	1.	Diurnal breathing loss 10 hour soak	( )	1
b. 60° - 86°F	2.	Diurnal breathing loss fuel tank heating and vapor collection	( )	2
c. 68° - 86°F	3.	Running loss test	( )	3
d. 60° - 84°F	4.	One hour hot soak	( )	4
e. 68° - 84°F				

2 8 2 6 H

Match the following engine malfunctions during a test stand start-up stated in Column 2 with their probable cause appearing in Column 1:

Column 1		Column 2		
a. Leak in gage line	606.	Engine starts, runs briefly then stops	( )	606
b. Fuel supply valve shut off	607.	Engine won't start	( )	607
c. Test stand ignition system not on	608.	Idle speed higher than initial setting	( )	608
d. Timing advanced	609.	Idle vacuum reading low	( )	609
e. Faulty ignition points	610.	Engine over-heats at light load	( )	610
f. Stand heat exchanger valves not open				
g. PCV valve stuck closed				

Answers: 1 - b, 2 - a, 3 - c, 4 a,

606 - b, 607 - c, 608 - d, 609 - a,

610 - f.

APPENDIX E

SAMPLE OF THE PRACTICAL TEST ITEM FORM

APPENDIX E

PRACTICAL EXAMINATION
FOR
EMISSION LABORATORY TECHNICIANS

PART I, LIGHT-DUTY VEHICLES

SECTION III

SYSTEM OPERATOR

3.1 CVS OPERATIONS

3.1.1 CVS Test Procedure

A. Did the technician:

1. Purge and evacuate bags? ___ ___ (3)

2. Perform leak check? ___ ___ (3)

3. Change filters? ___ ___ (3)

B. Were all the necessary temperatures and pressures recorded accurately? ___ ___ (1)

C. Did he follow the test sequence accurately? ___ ___ (5)

3.1.2 Propane injection calibration check

A. Was this procedure successfully done? ___ ___ (10)

B. If check was not successful, did technician locate and correct the problem? ___ ___ (10)

3.2 ANALYTICAL SYSTEM

3.2.1 Calibration of Analyzers

	Yes	No	
A. Calibration System leak checked prior to start of calibration?	___	___	(3)
B. Proper flow rates used and checked during calibration?	___	___	(5)
C. Primary standards used were properly identified and sufficient for constructing a calibration curve?	___	___	(5)
D. Check log of daily, weekly, monthly calibrations and checks. Does each entry contain date, results and signatures (or initials)?	___	___	(1)
E. Proper zero gas used on all instruments?	___	___	(3)
F. Calibration points were repeated within ± 1% of full scale or ±5% of measured value whichever is smaller?	___	___	(3)
G. Instrument zero checked between calibration points?	___	___	(3)
H. Proper converter operating temperature used and checked?	___	___	(3)
I. Checked agreement between primary output device (computer, DVM) and meter or recorder?	___	___	(3)

APPENDIX F

OPERATIONAL DEFINITION OF TERMS

APPENDIX F

OPERATIONAL DEFINITION OF TERMS

Content Validity: Content validity is evaluated by showing how well the content of the test samples the class of situations or subject matter about which conclusions are to be drawn. It is especially important in the case of achievement and proficiency measures. It is also known as "face validity" and "logical validity" and is described by the relevance of a test to different types of criteria, such as analyses of courses of study and jobs, statements of instructional objectives, analyses of textbooks, analyses of teachers' final-examination questions, pooled judgments of competent person, concepts of social utility, and logical or psychological analyses of mental processes, motor performances, or other behaviors.

Element: The smallest step into which it is practicable to subdivide any work acitivity without analyzing separate motions, movements and mental processes involved.

Heavy Duty Engine: Any engine which the engine manufacturer could reasonably expect to be used for motive power in a heavy duty vehicle.

Heavy Duty Vehicle: Any motor vehicle either designed primarily for transportation of property and rated at more than 6000 pounds GVW or designed primarily for transportation of persons and having a capacity of more than 12 persons.

Item (Test): A test question.

Item Analysis: Re-examining each item of a test for the purpose of discovering its strength and flaws.

Light Duty Vehicle (Cars and trucks): Any motor vehicle either designed primarily for transportation of property and rated at 6000 pounds GVW or less or designed primarily for transportation of persons and having a capacity of 12 persons or less.

Reliability: The consistency with which a test yields the same results in measuring whatever it does measure.

Task: A logically related set of actions required for the completion of a job objective.

Task Analysis: A full description or listing of all the tasks involved in a job including the required knowledge, skills, and abilities and other characteristics such as frequency of performance, degree of difficulty and importance.

Validity: The degree to which a test measures what it is intended to measure.

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16. ABSTRACT

The objective of the work described in this report was to develope a written and practical test for emission laboratory technicians as part of the EPA program for the certification of emission laboratories which conduct the EPA regulatory test. Olson Laboratories was assisted in the written test development by a technical review panel consisting of experienced representatives from the automobile manufacturers and independent laboratories. The panel assisted in the preparation of the task analysis, writing the test items, and item analysis. In addition to the written examination, a practical test was developed consisting of both a manipulative and oral test.

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