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ABSTRACT

This report is designed to provide information required to evaluate the Specific Aptitude Test Battery (SATB) for Airframe-and-Powerplant Mechanic from three points of view: (1) technical adequacy of the research, (2) fairness to minorities, and (3) usefulness of the battery to Employment Service staff and employers in selecting individuals for Airframe-and-Powerplant Mechanics positions. Research demonstrated a statistically significant and useful relationship between proficiency as an Airframe-and-Powerplant Mechanic and the following SATB: General Learning Ability, Verbal Aptitude, and Manual Dexterity. The validation sample consisted of 272 employed workers (including 30 blacks) from 14 states. Data were collected during 1973-1980. The tests used were the General Aptitude Test Battery. Job proficiency was measured by means of ratings by supervisors. No evidence of differences in validity for blacks and nonminorities was found. The SATB was found to be fair to both blacks and nonminorities using several definitions of fairness. The SATB can be expected to produce a useful increase in the proportion of highly competent workers. When the SATB was applied to the validation sample, an increase from 66 percent to 74 percent in the percentage of highly competent workers was found. Appended are: (1) a table of descriptive statistics for the black and nonminority subgroups of the validation sample, (2) the descriptive rating scale for supervisors, and (3) a sample Airframe-and-Powerplant Mechanic job description. (PN)

DEVELOPMENT OF USES SPECIFIC APTITUDE TEST BATTERY

for

AIRFRAME-AND-POWERPLANT MECHANIC
(aircraft-aerospace mfg.; air trans.) 621.281-014

S-111R85

Developed in Cooperation with the
Alaska, California, Colorado, Florida, Indiana, Louisiana, Michigan,
New Mexico, New York, Ohio, Oklahoma, Oregon, Pennsylvania and Washington
Employment Services

Analysis and Report

by

State of Oregon
Department of Human Resources
Employment Division
Test Development Unit

U.S. DEPARTMENT OF LABOR
Employment and Training Administration
United States Employment Service

1985

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South

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Pan Air Corporation, New Orleans, Louisiana
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West

Alaska Airlines, Anchorage, Alaska
Alaska Airlines, Fairbanks, Alaska
Northrop Institute of Technology, Inglewood, California
AIRCRAFTCO, Broomfield, Colorado
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GATB Study No. 3080

DEVELOPMENT OF USES SPECIFIC APTITUDE TEST PATTERY S-111R84

for

AIRFRAME-AND-POWERPLANT MECHANIC
(aircraft-aerospace mfg., air trans.) 621.281-014

RESEARCH SUMMARY

This report is designed to provide information required to evaluate the Specific Aptitude Test Battery (SATB) for Airframe-and-Powerplant Mechanic from three points of view: (1) technical adequacy of the research, (2) fairness to minorities and (3) usefulness of the battery to Employment Service staff and employers in selecting individuals for Airframe-and-Powerplant Mechanics positions.

Research demonstrated a statistically significant and useful relationship between proficiency as an Airframe-and-Powerplant Mechanic and the following Specific Aptitude Test Battery:

Aptitudes	Cutting Scores
G - General Learning Ability	85
V - Verbal Aptitude	90
M - Manual Dexterity	95

The validation sample consisted of 272 employed workers (including 30 blacks) from fourteen states. Data were collected during 1973-1980. The tests used were the General Aptitude Test Battery (GATB). Job proficiency was measured by means of ratings by the supervisors.

No evidence of differences in validity for blacks and nonminorities was found. The SATB was found to be fair to both blacks and nonminorities using several definitions of fairness. Additional information may be found in the Validity of the Battery section and in Appendix 1.

The SATB can be expected to produce a useful increase in the proportion of highly competent workers. When the SATB was applied to the validation sample, composed of individuals who were employed and therefore considered proficient, an increase from 66% to 74% in the percentage of highly competent workers was found.

PROCEDURE

A concurrent design was used for the validation study. Test and criterion were collected at the same time.

Job Analysis

A job analysis was performed by observing the workers' performance on the job and by consulting with their supervisors. On the basis of the job analysis, a job description was prepared which was used to select an experimental sample of employed workers performing basically the same job duties and to choose an appropriate criterion or measure of job performance.

At each location listed in ACKNOWLEDGEMENT, the job duties were compared with the job description and found to be essentially the same. If minor differences were found, the job description was modified. The job description shown in Appendix 3 is the result of this process and may be used to provide information on the applicability of the test battery resulting from this research.

In the validation sample job analysis, each job duty was rated for frequency of performance, percentage of time spent, and level of difficulty. Critical job duties were identified on the basis of these ratings.

At each location, at least one analyst rated the aptitudes as irrelevant, important, or critical to performance of job duties. A synthesis of these ratings and the rationale for their selection follows.

G - General Learning Ability	Required to learn and apply inspection methods to identify defects; to understand operating and maintenance manuals pertaining to specific airframe, electrical, hydraulic, powerplant and other systems; to determine cause of system or component malfunction; to plan repair and maintenance steps; and to understand instructions and work orders.

S - Spatial Aptitude	Required to read and comprehend schematics, drawings, plans or diagrams; to visualize relationships of various components when installing and maintaining electrical systems, adjusting or repairing switches and subassemblies; and to cut, shape, and bend sheet metal, tubing and other materials to make repairs or replacements according to manufacturers' specifications.
P - Form Perception	Required to visually perceive defects in airframe and powerplant components; to observe fit of parts and operating controls to determine needed replacement or repair; to visually check all circuits and connections for breaks or looseness; and to recognize components by their size, shape, and position.
F - Finger Dexterity	Required to rapidly and accurately remove and replace small parts and fastening devices using a variety of small hand tools; to disconnect and connect control cables, fuel lines and electrical wiring; to attach color-coded wires between specified component leads to make circuit connections; and to assemble, adjust, and align circuitry and components.

M - Manual Dexterity	Required to manipulate and position parts and components; to use hand and power tools to dismantle, adjust, repair and assemble airframe and powerplant system components; and to operate chain hoist and other equipment used to inflate tires, change oil, and lubricate fittings.

Experimental Test Battery

The experimental test battery for the validation sample, consisted of all 12 tests of the GATB. Information on the composition and developmental research of the GATB may be found in the Manual for the General Aptitude Test Battery, Section III, Development, available from the United States Government Printing Office.

Validation Sample Description

The sample consisted of 272 Airframe-and-Powerplant Mechanics (all males) employed in the North, South, and West (see ACKNOWLEDGEMENT). A total of 63 were minority group members (30 black, 8 American Indian, 9 Hispanic, 7 Oriental, and 9 "other") and 209 were nonminority group members. The means and standard deviations for age, education and experience of sample members are shown in Table 1.

All Airframe-and-Powerplant Mechanics had at least 19 months' experience on a job which had duties similar to those found in the job description in Appendix 3. Descriptive statistics for black and nonminority subgroups are shown in Appendix 1.

Criterion for Validation Study

The criterion consisted of supervisory ratings. The immediate supervisor rated each worker. The ratings were obtained by state test development analysts who explained the rating procedure to the supervisors in person. Two ratings were obtained from each supervisor with an interval of at least two weeks between the ratings. Since sample members' test scores are confidential, supervisors had no knowledge of the workers' scores.

The Descriptive Rating Scale was used. The Scale (Appendix 2) consists of six items. Five of these items cover different aspects of job performance. The sixth item is a global item on the "all-around" ability of the Airframe-and-Powerplant Mechanic. Each item has five alternative responses corresponding to different degrees of job proficiency. For the purpose of scoring the items, weights of 1 to 5 were assigned to the responses. The total score on the rating scale is the sum of the weights for the six items. The possible range is 6-30.

A review of the job description indicated that the subjects covered by the rating scale were directly related to important aspects of job performance.

A - Quantity of work: Airframe-and-Powerplant Mechanics are required to be sufficiently quick and efficient to make needed repairs and replacements to keep aircraft on schedule.

B - Quality of work: Airframe-and-Powerplant Mechanics are required to meet the qualitative work standards set by manufacturers' and FAA specifications.

C - Accuracy of work: Airframe-and-Powerplant Mechanics must meet an acceptable standard of accuracy in repair and replacement of system components.

D - Job knowledge: Airframe-and-Powerplant Mechanics must have sufficient knowledge of aircraft systems, components, and manufacturers' and FAA specifications.

E - Job versatility: Airframe-and-Powerplant Mechanics must be able to perform adequately on all aircraft systems and components.

F - "All-around" job ability: Airframe-and-Powerplant Mechanics' value to the employer involves a combination of all of the above aspects of job performance.

A reliability coefficient of .77 was obtained between the initial ratings and the second ratings, indicating a significant relationship. Therefore, the final criterion score consists of the combined scores of the two ratings. The possible range for the final criterion is 12-60. The actual range is 18-60. The mean is 45 with a standard deviation of 7.8. The relationships between the criterion and age, education, and experience is shown in Table 1 below.

TABLE 1

Means, Standard Deviations (SD), and Pearson Product-Moment Correlation (r) with the Criterion for Age, Education, and Experience

Validation Sample
N = 272

	Mean	SD	r
Age (years)	37.5	10.4	.0524
Education (years)	12.7	1.4	.1397 *
Total Experience (months)	174.2	109.7	.1857 **

* Significant at the .05 level
** Significant at the .01 level

For the purpose of this analysis, the criterion distribution was dichotomized so as to include, as nearly as possible, one-third in the low criterion group and two-thirds in the high criterion group. This is the standard procedure for SATB studies. A criterion cutting score of 43 placed 34% of the total sample in the low criterion group.

ANALYSIS

The initial step in the analysis is to identify those aptitudes which show some evidence of validity and job relatedness. Evidence can be any of the following:

1. Statistical evidence of the correlation (r) between the test and the criterion

2. Content validity as evidenced by a rating of "critical" based on the job analysis

3. Any combination of:

   a. high mean

   b. low standard deviation (SD)

   c. rating of "important" based on the job analysis

   d. demonstrated validity in a prior validation study

Statistical results for the validation sample are shown in Table 2.

TABLE 2

Statistical Results for Validation Sample

N = 272

Aptitude	Mean	SD	r	
G - General Learning Ability	103.9	15.5	.184	**
V - Verbal Aptitude	100.0	11.7	.171	**
N - Numerical Aptitude	99.0	15.5	.137	*
S - Spatial Aptitude	110.3	18.0	.141	*
P - Form Perception	108.8	20.3	.029	
Q - Clerical Perception	109.8	13.7	.048	
K - Motor Coordination	100.9	16.9	.111	
F - Finger Dexterity	97.6	20.9	.096	
M - Manual Dexterity	111.8	24.8	.126	*

* Significant at the .05 level
** Significant at the .01 level

Table 3 summarizes the qualitative analysis and statistical results shown in Table 2 and shows the aptitudes considered for inclusion in the battery.

TABLE 3

Summary of Qualitative and Quantitative Data for Validation Sample

Type of Evidence	Aptitudes								
	G	V	N	S	P	Q	K	F	M
Job Analysis Ratings									
Critical									
Important	X			X	X			X	X
Irrelevant									
Statistical Evidence									
High Mean				X	X	X			X
Low SD		X				X			
Significant r	X	X	X	X					X
Aptitudes Considered for Inclusion in the Battery	G	V	N	S	P	Q			M

The information in Table 3 indicates that the following aptitudes should be considered for inclusion in the battery: G, V, N, S, P, Q and M. Although a majority of analysts did not consider aptitude V as important for this job, the statistical evidence implies that it is important. A review of the job description (Appendix 3) did not contraindicate these aptitudes. The objective of the analysis is to develop a battery of two, three, or four aptitudes with cutting scores set at levels (a) where about the same percent will meet the cutting scores as the percent placed in the high criterion group and (b) which will maximize the relationship between the battery and the criterion.

The cutting scores are set at about one standard deviation below the mean aptitude scores of the sample, with the deviations at five point intervals above and below these points to achieve the objectives indicated above.

The following battery resulted:

Aptitudes	Cutting Scores
G - General Learning Ability	85
V - Verbal Aptitude	90
M - Manual Dexterity	95

VALIDITY OF THE BATTERY

This section of the report first presents evidence of criterion-related validity of the SATB on the validation sample and all relevant subsamples. Next, it provides information on effectiveness and fairness of test norms.

Criterion Related Validity

Table 4 shows that there is a significant relationship between the job performance criterion and the SATB for the validation sample in aggregate and each of its identifiable ethnic subgroups.

TABLE 4

Validity Of Battery

Sample	N	High Criterion Group		Low Criterion Group		Chi Square	Significance Level p/2	Phi Coefficient
		Below Cutting Scores	Meeting Cutting Scores	Below Cutting Scores	Meeting Cutting Scores			
Validation Total	272	51	128	48	45	14.1	.0005	.23
Black	30	6	8	12	4	2.0	.10	.26
Non-minority	209	37	106	31	35	9.2	.0025	.21

Multiple regression analysis was conducted between aptitudes G, V and M and the criterion. A multiple correlation of .20 was obtained, significant at the .01 level.

Effectiveness of the Battery

The level of validity shown in Table 4 indicates that the SATB will be useful in selection. In the total validation sample 66% were considered to be highly competent. Of those who met the cutting scores, 74% were highly competent, an increase of 8 percentage points over the existing selection method.

TABLE 5

Effectiveness of the Battery

		Highly Proficient (High Criterion Group)		Marginal (Low Criterion Group)	
Selection System	Number Selected	N	%	N	%
Validation Sample					
Without Tests	272	179	66	93	34
With Tests	173	128	74	45	26

The research sample consisted of employed workers on whom some selection had already taken place; presumably those workers who lacked the required abilities had quit, been fired, or had been transferred. Therefore, a greater increase over existing selection methods in the proportion of competent workers is to be expected when the battery is used for selection, as the range of relevant abilities is almost certainly greater among applicants than among employed workers.

Subgroup Analysis

No difference in the validities for blacks and nonminorities was found for this battery; the difference between phi coefficients for black and nonminority groups for the validation sample is not statistically significant (CR = 0.2577).

The battery is fair to blacks since the percent of both blacks and nonminorities who met the cutting scores approximated the percent who were in the high criterion group; 40% of the blacks met the cutting scores and 47% were in the high criterion group; 67% of the nonminorities met the cutting scores and 68% were in the high criterion group.

Prior Battery

Analysts tested previously validated norms for Airframe-and-Powerplant Mechanic, S-111R, on this validation sample. The original battery, validated in June, 1970 (N-90, S-100, F-85) was based on a student sample. This battery is not valid for the current revalidation sample.

APPENDIX 1

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Descriptive Statistics for Black and Nonminority Subgroups of Validation Sample

	Black (N = 30)			Nonminority (N = 209)		
Variable	Mean	SD	Range	Mean	SD	Range
Aptitude G	90.0	16.3	59-120	106.8	13.8	70-145
Aptitude V	93.9	12.2	72-125	101.7	11.0	68-135
Aptitude N	85.5	18.0	48-124	101.5	14.1	58-136
Aptitude S	96.1	16.0	68-133	112.4	17.1	74-156
Aptitude P	97.5	22.7	49-143	111.3	19.3	58-163
Aptitude Q	103.5	14.1	70-133	111.2	13.3	75-150
Aptitude K	96.4	22.8	27-136	101.4	16.4	53-140
Aptitude F	84.9	25.5	26-123	99.2	19.8	40-156
Aptitude M	98.8	26.6	35-151	113.3	24.3	29-171
Criterion	42.0	8.7	25-59	45.9	7.5	18-60
Age (Years	40.8	11.0	24-68	36.5	10.2	20-62
Education (Years)	12.2	1.5	8-15	12.8	1.4	7-19
Total Experience (months)	187.8	117.8	25-420	166.0	106.4	19-492

APPENDIX 2

U.S. DEPARTMENT OF LABOR • MANPOWER ADMINISTRATION

DESCRIPTIVE RATING SCALE

SCORE _____

RATING SCALE FOR _____

D.O.T. Title and Code

Directions. Please read the "Suggestions to Raters" and then fill in the items which follow. In making your ratings, only one box should be checked for each question.

SUGGESTIONS TO RATERS

We are asking you to rate the job performance of the people who work for you. These ratings will serve as a "yardstick" against which we can compare the test scores in this study. The ratings must give a true picture of each worker or this study will have very little value. You should try to give the most accurate ratings possible for each worker.

These ratings are strictly confidential and won't affect your workers in any way. Neither the ratings nor test scores of any workers will be shown to anybody in your company. We are interested only in "testing the tests." Ratings are needed only for those workers who are in the test study.

Workers who have not completed their training period, or who have not been on the job or under your supervision long enough for you to know how well they can perform this work should not be rated. Please inform the test technician about this if you are asked to rate any such workers.

Complete the last question only if the worker is no longer on the job.

In making ratings, don't let general impressions or some outstanding trait affect your judgment. Try to forget your personal feelings about the worker. Rate only on the work performed. Here are some more points which might help you:

1. Please read all directions and the rating scale thoroughly before rating.

2. For each question compare your workers with "workers-in-general" in this job. That is, compare your workers with other workers on this job that you have known. This is very important in small plants where there are only a few workers. We want the ratings to be based on the same standard in all the plants.

3. A suggested method is to rate all workers on one question at a time. The questions ask about different abilities of the workers. A worker may be good in one ability and poor in another: for example, a very slow worker may be accurate. So rate all workers on the first question, then rate all workers on the second question, and so on.

4. Practice and experience usually improve a worker's skill. However, one worker with six months' experience may be a better worker than another with six years' experience. Don't rate one worker as poorer than another merely because of a lesser amount of experience.

5. Rate the workers according to the work they have done over a period of several weeks or months. Don't rate just on the basis of one "good" day, or one "bad" day or some single incident. Think in terms of each worker's usual or typical performance.

6. Rate only the abilities listed on the rating sheet. Do not let factors such as cooperativeness, ability to get along with others, promptness and honesty influence your ratings. Although these aspects of a worker are important, they are of no value for this study as a "yardstick" against which to compare aptitude test scores.

STATE OF OREGON
EMPLOYMENT DIVISION
DEPARTMENT OF HUMAN RESOURCES
Form MA 7-66 (9-75) Page 1

NAME OF WORKER (Print) (Last) (First)

SEX: MALE_____ FEMALE_____

Company Job Title: _____

How often do you see this worker in a work situation?

- ☐ All the time.
- ☐ Several times a day.
- ☐ Several times a week.
- ☐ Seldom.

How long have you worked with this worker?

- ☐ Under one month.
- ☐ One to two months.
- ☐ Three to five months.
- ☐ Six months or more.

A How much can this worker get done? (Worker's ability to make efficient use of time and to work at high speed.) (If it is possible to rate only the quantity of work which a person can do on this job as adequate or inadequate, use #2 to indicate "inadequate" and #4 to indicate "adequate.")

- ☐ 1. Capable of very low work output. Can perform only at an unsatisfactory pace.
- ☐ 2. Capable of low work output. Can perform at a slow pace.
- ☐ 3. Capable of fair work output. Can perform at an acceptable pace.
- ☐ 4. Capable of high work output. Can perform at a fast pace.
- ☐ 5. Capable of very high work output. Can perform at an unusually fast pace.

B. How good is the quality of work? (Worker's ability to do high-grade work which meets quality standards.)

- ☐ 1. Performance is inferior and almost never meets minimum quality standards.
- ☐ 2. Performance is usually acceptable but somewhat inferior in quality.
- ☐ 3. Performance is acceptable but usually not superior in quality.
- ☐ 4. Performance is usually superior in quality.
- ☐ 5. Performance is almost always of the highest quality.

C. How accurate is the work? (Worker's ability to avoid making mistakes.)

- ☐ 1. Makes very many mistakes. Work needs constant checking.
- ☐ 2. Makes frequent mistakes. Work needs more checking than is desirable.
- ☐ 3. Makes mistakes occasionally. Work needs only normal checking.
- ☐ 4. Makes few mistakes. Work seldom needs checking.
- ☐ 5. Rarely makes a mistake. Work almost never needs checking.

D. How much does the worker know about the job? (Worker's understanding of the principles, equipment, materials and methods that have to do directly or indirectly with the work.)

- ☐ 1. Has very limited knowledge. Does not know enough to do the job adequately.
- ☐ 2. Has little knowledge. Knows enough to get by.
- ☐ 3. Has moderate amount of knowledge. Knows enough to do fair work.
- ☐ 4. Has broad knowledge. Knows enough to do good work.
- ☐ 5. Has complete knowledge. Knows the job thoroughly.

E. How large a variety of job duties can the worker perform efficiently? (Worker's ability to handle several different operations.)

- ☐ 1. Cannot perform different operations adequately.
- ☐ 2. Can perform a limited number of different operations efficiently.
- ☐ 3. Can perform several different operations with reasonable efficiency.
- ☐ 4. Can perform many different operations efficiently.
- ☐ 5. Can perform an unusually large variety of different operations efficiently.

F. Considering all the factors already rated, and only these factors, how good is this worker? (Worker's all-around ability to do the job.)

- ☐ 1. Performance usually not acceptable.
- ☐ 2. Performance somewhat inferior.
- ☐ 3. A fairly proficient worker.
- ☐ 4. Performance usually superior.
- ☐ 5. An unusually competent worker.

Complete the following ONLY if the worker is no longer on the job.

G. What do you think is the reason this person left the job? (It is not necessary to show the official reason if you feel that there is another reason, as this form will not be shown to anybody in the company.)

- ☐ 1. Fired because of inability to do the job.
- ☐ 2. Quit, and I feel that it was because of difficulty doing the job.
- ☐ 3. Fired or laid off for reasons other than ability to do the job (i.e., absenteeism, reduction in force).
- ☐ 4. Quit, and I feel the reason for quitting was not related to ability to do the job.
- ☐ 5. Quit or was promoted or reassigned because the worker had learned the job well and wanted to advance.

RATED BY	TITLE	DATE
COMPANY OR ORGANIZATION	LOCATION (City, State, ZIP Code)	

Form MA 7-66 (9-75) Page 3

APPENDIX 3

JOB DESCRIPTION

Job Title S-111R84

AIRFRAME-AND-POWERPLANT MECHANIC (aircraft-aerospace mfg.; air trans.) 621.281-014

Guide for Occupational Exploration (GOE) Code 05.05.09 Mechanical Work

Job Summary

Inspects, services, repairs, replaces airframe and powerplant components and subassemblies in conformity with accepted practices.

Work Performed

Reviews work order or schedule to determine repair manual, test equipment, tools and materials needed for job.

* Inspects aircraft visually or by use of test instruments to determine overall condition of airframe or powerplant. Performs detailed tests and inspections to determine condition and possible repair replacement of parts. Consults manufacturers' manuals, company manuals and Federal directives for specifications to determine repair or replacement to correct malfunction.

Performs routine repairs. Trims cracks and smooths holes in metal surfaces. Cuts and replaces patch over hole using proper tools. Cuts copper or plastic tubing to replace damaged fuel or oil lines, repairs or replaces damaged control cables. Repairs damaged metal structural members such as ribs or spars using riveting or welding equipment.

* Repairs landing gear. Supports fuselage on jacks while moving landing gear parts. May reline brakes, grease and install wheel bearings, replace or repair tires, damaged springs and hydraulic cylinders. May repair landing gear strut.

Removes engine. Disconnects wires, fuel lines, engine controls and accessories. Attaches hoses to engine for support, unbolts engine mount from firewall and removes engine from fuselage, wings or tail. Lifts engine from aircraft by chain hoist or forklift truck.

* Dismantles, examines, repairs, re-installs and tests engine. Removes all remaining accessories such as carburetor, air heater, cooler, starter, fuel and oil pumps. Removes engine components such as push rods, housings, valves, crank shaft and pistons; on jet aircraft may remove or inspect turbine blades and gears to detect breaks, fractures or excessive wear. Replaces or repairs worn, cracked damaged or broken components using ignition analyzer, compression checker, distribution timer and ammeter. Reassembles engine parts and components. Installs engine and tests for proper operation.

* Removes or installs wing or tail assembly. Disconnects wires and control cables from wings, rudder or elevator. Lifts worn or damaged assembly from aircraft. Replaces repaired or new assembly to fuselage and connects all parts.

* Services aircraft. Inflates tires, fills fuel tanks, changes oil, lubricates fittings and cleans mechanical parts.

Certification by Federal Aviation Administration (FAA) may be required.

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* These job duties were designated as critical job duties because they must be performed competently if the job is to be performed in a satisfactory manner. Workers spend an estimated 65% of their time performing these tasks.