FINAL REPORT: HIGHWAY COMPETENCY SURVEY

Presented to:

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Executive Summary

This document reports the findings of a study conducted for the Auburn University Highway Research Center during the period October 1, 1991 to September 30, 1992. It assesses the competencies, skills, and tasks relevant to entry level highway construction technicians and equipment operators in the highway construction industry within the state of Alabama. The assessment provides the following:

1. An estimate of the size of the workforce and the annual requirement for entry level workers. This provides the number of workers needed.

2. A relative measure of the number of applicants for existing vacancies within the industry, by career field. This indicates how many workers are actively seeking employment in each field, and allows comparison between fields.

3. A relative measure of the difficulty in finding qualified applicants. This indicates the need for pre-employment training in each field, and allows comparison between fields.

4. An industry validated list of competencies recommended for entry level highway construction technician and equipment operators. This can be used by curriculum builders should the decision be made to create pre-employment training courses in any of these fields.

5. A detailed occupational analysis of entry level competency requirements for the Construction Materials Technical career field, specifically addressing academic skills. This can be used by curriculum builders should the decision be

made to create pre-employment training courses in this particular field.

6. Of the job categories reviewed, this study indicated the most critical need was for trained and qualified construction materials technicians. It is recommended consideration be given to establishing a pre-employment training program to alleviate this need.

Highway Construction Competency Study

Research problem

Determine the competencies, skills, and tasks relevant to entry level highway construction technician and equipment operator positions in the highway construction industry in the state of Alabama.

Context

The Advisory Committee of the Auburn University Highway Research Center identified a critical shortage of adequately trained highway construction technicians and equipment operators. Limited educational training programs for such entry level positions are available within the State. Both government and private industry are forced to train and develop personnel through on-the-job training. This is expensive and requires an inordinately long lead time for filling key technical positions. Under a grant from the Highway Research Center, the Economic Development Institute initiated a survey of highway construction firms and government agencies to assess educational and training needs in the highway construction industry in the state of Alabama. Dr. Bettye B. Burkhalter, Director of EDI, is Project Director. Mr. W. L. Lett, Associate Director of EDI, coordinated data collection, analysis, and generation of this final report. Dr. J. W. Selman and H. R. Horne, Jr. of the Vocational and Adult Education Department, Auburn University, designed and administered the survey, analyzed the data, and prepared the final report.

Subjects

Subjects consisted of private firms and government agencies active in the highway construction industry in the state of Alabama. For the purpose of this research, highway construction was operationally defined as construction of public roads and bridges. A listing of private firms active in the road-building industry in the state was obtained from the Alabama Roadbuilders Association and another from the Alabama Development Office. These listings were cross-checked against one another, and it was determined that over 300 private firms within the state describe themselves as being actively engaged in paving and road-building activities. This group was further qualified by eliminating all contractors who were not bonded to bid on state, city or county road projects. A final group of 55 in-state companies which actively bid on such contracts was identified. In addition, six private road-building firms based in other states were identified as participating in road-building activities within the state and as meeting the criteria of being bonded and bidding on state, city or county highway projects. Through interviews with State Highway Department representatives, a total of 81 governmental agencies were identified as participating in road-building activities. The 55 in-state companies, 6 out of state companies, and 81 government agencies were contacted by telephone, and their participation in the study was solicited.

Among in-state private companies and government agencies, all contacted (n=136) initially agreed to participate in the study. Out-of-state companies were not as willing to participate: only 1 of the 6 contacted agreed to participate in the survey, and that survey form was never returned. From 136 surveys mailed to

Alabama firms and governmental agencies, 94 were completed and returned for a 69% participation rate. In-state private firms had the best response rate, 76% (42 of 55). The response rate for government agencies was 64% (52 of 81). Non-responders were contacted by telephone to determine if there was any bias in terms of number or types of employees between responders and non-responders. Based on the telephone follow up of non-responders, no such bias was detected.

Because of the non-participation of the out-of-state firms, the scope of the study is limited to Alabama firms and government agencies. Moreover, this study is limited to career fields within a defined area and industry. This definition excludes other governmental agencies, private industries, or other organizations which utilize many of the same skills and could have many of the same employee requirements. Any generalization of the study results beyond the reference frame should be avoided.

Procedures

Instrument Development:

The first step included a review of the literature and assembly of background data. This information was used to identify tentative job skill listings and associated tasks. Personal interviews were then conducted with key professionals and major employers in the highway construction industry, including both private industry and government agencies. Based on these interviews, a survey instrument was developed. The initial instrument was an extensive listing of competencies in all areas, with the participants being asked to mark those competencies which they believed to be needed by entry level employees. This

initial instrument was refined through an interview process, and evolved into a two part survey. Part one of the survey asked employers to provide numbers and types of workers employed, and solicited subjective measures of the average number of applicants for vacancies and average number of qualified applicants for vacancies. Part one was designed to be completed by all participants. Part two offered participants a list of competencies developed through research and early interviews, and asked the participants to mark competencies they believed entry level workers should possess. This was the same format as the original instrument; however, as administered, part two normally contained competencies from two of the following job categories:

1. Construction Materials Technician
2. Engineering Assistant, Surveyor's Helper or Assistant, and Draftsman (topographic, cartographic and civil, plus cartographic technician).
3. Heavy Equipment Operator (earthmoving)
4. Heavy Equipment Operator, Asphalt (includes asphalt plant operator)
5. Heavy Equipment Operator (other)

Determination of which job category would be sent to a particular respondent was determined during the original telephone contact, by asking which categories were used by the company. The intent was to have organizations choose among competencies for job categories with which they were familiar. A successful pilot test of the two part instrument was conducted, followed by full scale administration to the population. As planned, Part one, addressing the size of the labor pool for each job category, was administered to all subjects. Part two, identification of

needed skills and competencies, was distributed to ensure each category could be validated by at least twenty representative organizations.

Data Collection:

Organization leaders were initially interviewed by telephone, and their support for the survey was solicited. Each leader was asked to provide access to an individual who was knowledgeable of the organization's experiences in hiring and training highway construction personnel. The survey form was mailed to the identified contact person as soon as possible following the original telephone call. Follow up was accomplished as required. Where no written response was received, efforts were made to complete the survey by telephone or personal interview. Non-responders were compared to responders in terms of numbers or types of employees, to determine whether there was a response bias in these areas of interest.

Data Analysis:

The telephone interviews with employers were used to categorize these employers in terms of number and types of employees, and to gather general employer perceptions of the state of the industry and entry level training needs. Data from the instrument were processed using the SPSS/PC program, to develop frequencies, percentages and rank. Initial results were evaluated, and a second cycle of interviews with selected key experts in the field was begun to provide resolution to questions on observations from the instrument, validate interpretations of survey results with industry experts, and provide a final formative evaluation in preparation of this report.

Analysis Process

The first item of analysis concerned estimation of the size of the workforce and the annual requirement for entry level workers, obtained by summing the stated numbers and requirements by category from all respondents. These respondents made up 69% of the identified population in terms of numbers of organizations. Because we could detect no bias in size of organization between responders and non responders, the operational assumption was made that these organizations made up 69% of population in terms of numbers of individuals involved. This sample was then projected against the universe to arrive at an estimate of numbers of workers involved in the highway construction industry and an estimate of the number of entry level workers required annually by the industry.

There are several caveats involved in the projection:

1. The definition of the highway construction industry as used in this study was narrow. In defining a numerical requirement for a specific job category, that requirement is only applicable within the narrow frame of the industry description.
2. The definitions of equipment operator skill categories were broad. For example, Earthmoving Heavy Equipment Operator category includes: Bulldozer Operator, Tractor/Back Hoe Operator, Motor Grader Operator, Self-Propelled Compaction Equipment Operator, Power Shovel Operator, and Scraper Operator. These were combined to reduce the size of the survey. Such a combination appeared to be reasonable because normal industry procedures often involve operation of more than one type of equipment in this category, meaning an employee could expected to operate several types of equipment within this

category. This is true in both private industry and government (especially at the county level). As there is overlap between job titles within categories, there is some overlap between categories, depending upon individual employer definitions of job tasks. For example, some overlap was noted between engineering assistants and heavy equipment operators.

After estimating the size of the workforce and the annual requirement for entry level workers, the next area of analysis involved the relative measure of the number of applicants for existing vacancies in the career field. The purpose of this analysis was to provide a subjective picture of the number of applicants actively seeking employment in this field, and to allow comparison between fields. A subjective approach was used because hard data on the number of applicants per vacancy is not generally available. Participants were asked to provide their perception of the normal number of applicants per vacancy, rated on a scale from 0 to five, with 0 indicating few to no applicants and 5 indicating five or more applicants. The rationale for using this scale was based upon information provided during development of the instrument. Hiring officials tended to categorize recollected numbers of applicants as ranging from "just a few" or "almost none" through 2, 3, and 4 to "a lot" or "a great many". Employers were asked how many applicants they normally received for each vacancy, and asked to mark the appropriate answer on a scale from 0 to 5. The number "5" was used in the survey to express values equal to or greater than 5. The 0 value expressed "few to none". This same procedure was used regarding qualified applicants per vacancy. The values shown in the tables under "applicants per vacancy" and

"qualified applicants per vacancy" are therefore relative values, and are not on a scale of equal intervals. These data are intended as a subjective picture of employee demand for specific jobs and qualification level of prospective employees. They may also be used for comparison of relative numbers between jobs, but not as statements of actual numbers of applicants or qualified applicants.

Part two of the survey instrument provided a competency list by job category and asked respondents to indicate which competencies would be required of an entry level worker. Response frequencies and percentiles were tabulated to provide an indication of the number of employers who believed this competency to be needed by an entry level worker. "Needed" is not as strong a descriptor as many employers wished to use; however, "essential" or "necessary" would be misleading because, according to interviews, current practice is that in most cases ALL competencies are learned on the job. Specific competencies are typically desired by employers, and mastery of these competencies prior to employment would make a prospective employee more attractive; however, because current practice is to hire without the competency, it might be misleading to designate the competency as being required for employment of entry level employees.

Results

Summary tables I through IV provide an over-all view of the conditions within the industry regarding: (a) the need for entry level workers; (b) the availability of entry level workers expressed in a subjective rating of the numbers of individuals applying for vacancies in specific career areas; and (c) the need for formal training for these entry level workers. The need for training is expressed

both as a subjective rating of the numbers of qualified individuals applying for vacancies, and as a ratio of the numbers of qualified applicants versus the number of applicants.

SUMMARY TABLE I is a compilation of numbers of individuals hired by job category, and of estimated annual openings for entry level workers. These numbers are estimates based upon projecting a 69% sample against a demographically similar population.

SUMMARY TABLE I *

Job Category	# of employees	annual requirement
Construction Materials Technician	275 +- 7	59 +-2
Engineering Assistant	955 +-40	125 +-6
Surveyor's Helper or Assistant	300 +-12	88 +-4
Draftsman (topographic, cartographic and civil, plus cartographic technician)	185 +-6	42 +-2
Heavy Equipment Operator (earthmoving)	1784 +-40	468 +-20
Heavy Equipment Operator, Asphalt (includes asphalt plant operator)	619 +-18	158 +-6
Heavy Equipment Operator (other)	1377 +-36	284 +-8
* Confidence Factors: The +- values were computed using the values of two standard deviations either side of the sample mean. The actual value should have greater than a 95% probability of falling within the bounded values.		

The numbers provided in some areas of Summary Table I require comment. First, based upon interviews with experts in the field, the indicated annual requirement for construction materials technicians is likely to be lower than the actual requirement. Ongoing changes in the contracting process apparently have

acted to cause an underestimation of the requirement. In terms of contract specifications, the State Highway Department appears to be in transition from almost exclusive use of "method" specifications toward use of more "end result" specifications. Contractors are becoming responsible for quality control testing in the construction process where in the past the state was responsible for such testing. This means that there is an increased requirement on the part of private industry for construction materials technicians, both in companies directly involved in construction and in specialized testing laboratories. A lag between the need for increased testing and the requirement to hire additional testers is likely to have resulted in under-reporting of openings for entry level construction materials technicians. The increase in private industry was not matched by a corresponding decrease in the public sector because government agencies still require construction materials technicians for quality assurance and final product testing.

From interviews with numerous industry experts, the trend in the industry seems to be toward increasing accountability through testing at all levels of operation. Because many companies have no past history of employment for this category of employee, their present requirement may have been understated. Interviews conducted in the late stages of the study support the likelihood of underestimation of need for construction materials technicians. Even as present requirements may be understated, future requirements are growing as contract specifications become increasingly "end result" oriented. The trend toward "end result" specifications will likely continue, because it is apparently perceived as the most cost effective approach for many projects.

Second, there is overlap in job classifications, which suggests that the need for engineering assistants may be lower than indicated, and the need for heavy equipment operators higher. Review of completed survey instruments and interviews with the respondents revealed that some employers apparently classify various types of heavy equipment operators as engineering assistants - or require their engineering assistants to operate such machinery, which is essentially the same thing. The result is that the numbers on engineering assistants employed may be artificially high by a factor of approximately 100 employees and heavy equipment operator fields (except asphalt) artificially low by the same factor.

It may be useful to consider the annual requirement in terms of percentage of the workforce. Table I-A is a repetition of the data from Summary Table I, except for the inclusion of the annual requirement stated as a percentage of the workforce. The percentage is the figure in brackets below the annual requirement.

SUMMARY TABLE I-A

Job Category	# of employees	annual requirement
Construction Materials Technician	275	59 [21%]
Engineering Assistant	955	125 [13%]
Surveyor's Helper or Assistant	300	88 [29%]
Draftsman (topographic, cartographic and civil, plus cartographic technician)	185	42 [23%]
Heavy Equipment Operator (earthmoving)	1784	468 [26%]
Heavy Equipment Operator, Asphalt (includes asphalt plant operator)	619	158 [25%]
Heavy Equipment Operator (other)	1377	284 [21%]

With the exception of engineering assistants, the annual requirements as a percentage of the workforce seem relatively consistent. This study did not attempt to address the reasons behind the requirements for new workers (i.e. turnover or growth), or to investigate the relatively low reported requirement percentage in the engineering assistant area. It may be that the engineering assistant field is losing job descriptions to other areas. The trend noted earlier toward classifying some heavy equipment operators as engineering assistants may be self-correcting, with job descriptions being changed, thus reducing the annual requirement. Or, there may be less turnover in this field. Further study may be called for.

On the following page, SUMMARY TABLE II, Applicants and Qualified Applicants Per Vacancy, provides the employers' perceptions of the number of applicants per vacancy, and of the number of those applicants which are qualified. The purpose of Table II is to provide a sense of how many applicants are actively seeking employment in a particular field - expressed as applicants per job, and of how many of those meet the employers' desired entry level qualifications. The data are averages from the 94 responses received. Each respondent provided their perception of the number of applicants per vacancy (for the categories in which they employed workers), expressed as a number between 0 and 5. These responses were averaged to give the data presented in "0-5 scale applicants per vacancy". The same procedure was used to determine the averages for "0-5 scale qualified applicants per vacancy." These data are presented on a similar scale, and may be compared between job categories.

The Q/A factor is an operational construct which indicates the perceived

difficulty level in finding qualified applicants for positions, computed by dividing the number of qualified applicants in each case by the number of applicants in each case, then averaging the result of this operation. It allows comparison of the relative difficulty in locating qualified entry level employees between career fields. A number approaching a value of one indicates that employers generally perceive that the number of applicants and the number of qualified applicants are approximately equal. A fractional value below 1 indicates the degree to which qualified applicants make up the total pool of applicants. The lowest possible value is .20.

SUMMARY TABLE II

Job Title	0-5 scale applicants per vacancy	0-5 scale qualified applicants per vacancy	Q/A
Construction Materials Tech.	2.0	1.2	.66
Engineering Assistant	3.2	2.0	.68
Surveyor's Helper or Asst.	3.4	1.9	.62
Draftsman	2.3	1.7	.85
Heavy Equipment Operator (earthmoving)	3.9	1.9	.53
Heavy Equipment Operator (asphalt)	3.3	1.5	.54
Heavy Equipment Operator (other)	3.9	1.9	.51

The only job title which reported no applicants was that of construction materials technician. Of 48 respondents which reported employing this category of employee, seven, or 14.5%, reported zero applicants for existing positions.

SUMMARY TABLE III, Employee Requirements and Q/A Factor. This table places the Q/A factor alongside the annual requirement, expressed both as a number and a percentage of the number of employees. Relative need for pre-employment training and the size of the force to be trained can be examined and compared.

SUMMARY TABLE III

Job Category	# of employees	annual requirement	Q/A
Construction Materials Technician	275	59 [21%]	.66
Engineering Assistant	955	125 [13%]	.68
Surveyor's Helper or Assistant	300	88 [29%]	.62
Draftsman	185	42 [23%]	.85
Heavy Equipment Operator (earthmoving)	1784	468 [26%]	.53
Heavy Equipment Operator (asphalt)	619	158 [25%]	.54
Heavy Equipment Operator (other)	1377	284 [21%]	.51

SUMMARY TABLE IV, Employee Requirements and Q/A Factor. The average number of applicants may be used as an indicator of the number of people who are actively seeking such jobs. This table allows comparison between job categories in terms of annual requirements, average number of applicants per job, and Q/A factor.

SUMMARY TABLE IV

Job Title	annual requirement	average applicants	Q/A
Construction Mat. Technician	59	2.0	.66
Engineering Asst.	125	3.2	.68
Surveyor's Helper or Assistant	88	3.4	.62
Draftsman	42	2.3	.85
Heavy Equipment Op. (earthmoving)	468	3.9	.53
Heavy Equipment Operator (asphalt)	158	3.3	.54
Heavy Equipment Op. (other)	284	3.9	.51

Industry Validated Competency Lists

Competency lists are presented as a series of seven annexes to this study, one for each job category. These lists have been screened by knowledgeable members of the industry. Within each category, competencies are presented in the order of the frequency with which they were chosen as being needed for entry level workers. The guidance given in the survey instrument asked that employers indicate which competencies they would expect an entry level worker to possess prior to being hired, and which the worker could be expected to perform with little or no supervision. Where multiple individuals were required for a task, employers were asked to assume that the entry level worker would be expected to perform the least demanding functions of the task.

Annexes

A. CONSTRUCTION MATERIALS TECHNICIAN.

B. SURVEYOR'S HELPER/ASSISTANT.

C. DRAFTSMAN (CARTOGRAPHIC, TOPOGRAPHIC, CIVIL, and CARTOGRAPHIC TECHNICIAN).

D. ENGINEERING ASSISTANT.

E. EARTHMOVING EQUIPMENT OPERATOR (BULLDOZER, TRACTOR/BACK-HOE, MOTOR GRADER, SELF PROPELLED COMPACTION, POWER SHOVEL, SCRAPER).

F. ASPHALT EQUIPMENT OPERATOR (ASPHALT LAYDOWN MACHINE, SELF PROPELLED SPREADER, RECYCLING MACHINE, ASPHALT DISTRIBUTOR, PUGMILL, and ASPHALT PLANT OPERATOR).

G. HEAVY EQUIPMENT OPERATOR - OTHER (CHERRY PICKER, FORKLIFT, TRACTOR CRANE, TRUCK DRIVER, VACUUM SWEEPER, MUD JACK, STRIPING EQUIPMENT).

These annexes contain individual competency lists for each job area within the annex.

Conclusions

The Advisory Committee of the Auburn University Highway Research Center identified a perception within the industry of a critical shortage of adequately trained highway construction technicians and equipment operators. This perception was strongly supported in all interviews with employers. In addition to

traditional job competencies, academic shortfalls in reading and writing - especially the ability to read and follow directions - were noted, as was a shortfall in the ability of the employees to interpret and solve simple mathematical problems involving the use of fractions, percentages, and equations. For the most part, these shortfalls were noted in high school graduates, who, according to the Alabama Course of Study (Mathematics and Language Arts), should have mastered these skills by the end of the seventh or eighth grade. Except for drafting, pre-employment or vocational training programs for entry level positions in the highway construction industry are extremely limited within Alabama and the surrounding states. Drafting career fields appear to have the most opportunities for a prospective employee to receive pre-employment training. This is supported by the study data indicating a higher percentage of qualified applicants (Q/A .85) in drafting compared with the other areas (Q/A ranging from .51 to .68).

The perception within the industry that both government and private firms are being forced to train and develop personnel primarily through on-the-job training was strongly supported in interviews. The study data indicate that while in some categories many applicants are unqualified for entry level positions, a number of qualified entry level applicants was apparently available to meet the employers needs. However, this may indicate a difference between what the employers want, and what they are willing to accept. Post-survey interviews supported the contention that the qualified applicants column on the survey may have been used to indicate the number of acceptable - but unqualified - applicants rather than qualified applicants.

The perceived number of applicants per job varies from an average of 2 (construction materials technician) to almost 4 in the non-asphalt heavy equipment operator fields. Construction materials technician was the field with the lowest number of applicants - with 14% of the employers reporting few to no applicants.

Interviews indicate a stronger need for pre-employment training for construction materials technicians than for the other career fields. This is somewhat inconsistent with the data in Summary Table IV which show a relatively high Q/A coupled with a low number of average applicants. Part of the inconsistency can be explained by the argument presented earlier that the high Q/A is more a reflection of the number of "acceptably unqualified" applicants than a reflection of a large number of qualified applicants. The remainder of the inconsistency can be explained by the annual requirement for entry level construction material technicians having been underestimated. The number of openings is growing, and is predicted to continue its growth. Given the trend toward "end result" specifications, an increasing number of construction materials technicians will be required by private industry. Government requirements should remain relatively stable, except for fluctuations caused by increased construction activity. An increase in construction activity appears to be forthcoming, fueled by state and federally funded highway projects - both in new construction and in repair and maintenance of existing structure. Interviews with industry representatives indicate the amount of asphalt being laid in highway construction projects is approximately double that of this point last year.

In summary, the observed perception within the highway construction industry that there is a strong need for a public program to train construction materials technicians appears to be supported by: (a) survey data showing construction materials technician as the only field reporting few to no applicants for jobs in a sizable percentage of the reports (14%); (b) the contracting trend toward "end result" specifications which increases the need for trained technicians; and (c) proposed increases in highway construction activity. Such a program could also serve the public interest through offering certification programs in this field. It is recommended consideration be given to establishing a pre-employment training program for construction material technicians.

Annexes

A. CONSTRUCTION MATERIALS TECHNICIAN.

B. SURVEYOR'S HELPER.

C. DRAFTSMAN (CARTOGRAPHIC, TOPOGRAPHIC, CIVIL, and CARTOGRAPHIC TECHNICIAN).

D. ENGINEERING ASSISTANT.

E. EARTHMOVING EQUIPMENT OPERATOR (BULLDOZER, TRACTOR/BACK-HOE, MOTOR GRADER, SELF PROPELLED COMPACTION, POWER SHOVEL, SCRAPER).

F. ASPHALT EQUIPMENT OPERATOR (ASPHALT LAYDOWN MACHINE, SELF PROPELLED SPREADER, RECYCLING MACHINE, ASPHALT DISTRIBUTOR, PUGMILL, and ASPHALT PLANT OPERATOR).

G. HEAVY EQUIPMENT OPERATOR - OTHER (CHERRY PICKER, FORKLIFT, TRACTOR CRANE, TRUCK DRIVER, STRIPING EQUIPMENT).

ANNEX A: Construction Materials Technician

Narrative job description: Takes samples of highway (including roads, culverts, bridges, etc.) materials and prepares these for testing in the field and in the laboratory. Performs standard (ASTM or AASHTO) tests upon these materials using specified equipment, and reports the results of the tests. An outline of sampling and testing capability requirements, defined in terms of standard American Association of State Highway and Transportation Officials (AASHTO) tests is provided in the Construction Materials Technician table. The listed tests were compiled from industry inputs, and were verified with industry employers. However, these tests are not the end of the requirement, because within the listed tests an additional 68 AASHTO tests or specifications are referenced. In some cases tests and standards other than AASHTOs are referenced. The study references AASHTO tests where possible as they are, according to interviews, the tests and standards most often used by government and private industry in the highway construction industry in the state of Alabama.

The Dictionary of Occupational Titles, 1977 Edition (U.S. Employment Service, 1988) does not list Construction Materials Technician as a specific job title. However, the duties involved in performing this job contain elements of the following job classifications:

579.484-010 TESTER (Minerals and Earths, Mining and Quarrying)

011.361-010 TESTER (physical tester; testing machine operator)

019.161-014 TEST TECHNICIAN (Profess & kin.)

182.267-010 CONSTRUCTION INSPECTOR

Construction Materials Technician: Rank is based upon the number of employers who chose a particular competency as being needed by entry level employees. The number 1 ranked competency is the competency most often chosen. Percent indicated is the percentage of employers from the sample who chose the competency as being needed by entry level employees.

Table A: Construction Materials Technician

Competency	Rank	Percent
Test for slump of portland cement concrete (ASTM C 143-78, AASHTO T-119-82).	1	98%
Make and cure concrete test specimens in the field (ASTM C 31-88, AASHTO T-23-90).	2	94%
Determine the moisture content of soil (ASTM D 2216, AASHTO T-265-86).	3	92%
Prepare soil samples for particle size analysis and determination of soil constants (ASTM D 421).	4	86%
Test for sieve or screen analysis of fine and coarse aggregates (ASTM C 136-80, AASHTO T-27-88).	5	82%
Test for air content of freshly mixed concrete by volumetric method (ASTM C 173-78, AASHTO T-196-80).	6	78%
Make particle size analysis of soils (ASTM D 422, AASHTO T-88).	tie 7	71%
Determine density of soil in place by sandcone method (ASTM D 1556, AASHTO T-191-86).	tie 7	71%
Check measurements and computations made by others.	tie 7	71%
Secure and prepare for testing samples of aggregates, bituminous mixes, and soils.	10	69%
Determine moisture content of soil and soil aggregate in place by nuclear method (ASTM D 3017, AASHTO T-239-90).	tie 11	63%

Determine liquid limit of soils (ASTM D 423, AASHTO T-89-90).	tie 11	63%
Determine plastic limit and plasticity index of soils (ASTM D 424, AASHTO T-90-87).	tie 13	61%
Determine density of soil and soil aggregate in place by nuclear method (ASTM D 2922, AASHTO T-238-86).	tie 13	61%
Determine one-dimensional consolidation properties of soils (ASTM D 2435, AASHTO T-216-83).	15	59%
Determine specific gravity of soils (ASTM D 854, AASHTO T-100-90).	16	57%
Determine moisture density relations of soils and soil aggregate using 5.5 lb rammer (ASTM D 698, AASHTO T-99-90) and 10 lb rammer (ASTM D 1557, AASHTO T-180-90).	tie 17	55%
Test for surface moisture in fine aggregate (ASTM C 70-79, AASHTO T-142-81).	tie 17	55%
Make cure concrete test specimens in laboratory (ASTM C 192-88, AASHTO T-126-90).	19	53%
Test for compressive strength of cylindrical concrete specimens (ASTM C 39-86, AASHTO T-22-90).	20	47%
Test for specific gravity and absorption of coarse aggregate (ASTM C 127-84, AASHTO T-85-88).	tie 21	43%
Test for specific gravity and absorption of fine aggregate (ASTM C 128-84, AASHTO T-84-88).	tie 21	43%
Test for maximum specific gravity of paving mixtures (ASTM D 2041, AASHTO T-209-90).	23	41%
Test for asphalt content of bituminous mixtures by the nuclear method (ASTM D 4125-83, AASHTO T-287-90).	24	37%
Test for sieve or screen analysis of fine and coarse aggregates (ASTM C 136-80, AASHTO T-27-88).	tie 25	35%
Determine bulk specific gravity of compacted bituminous mixtures (ASTM D 1188-56, AASHTO T-166-88).	tie 25	35%
Perform quantitative extraction from bituminous paving mixtures (ASTM D 2172-67, AASHTO T-164-90).	tie 25	35%

Determine density of soil in place by rubber-balloon method (ASTM D 2167, AASHTO T-205-86).	28	27%
Determine permeability of a soil by falling head and constant head methods.	tie 29	22%
Test for compressive strength of bituminous mixes (ASTM D 1074-80, AASHTO T-167-84).	tie 29	22%
Determine resistance of plastic flow of bituminous mixtures using Marshall apparatus (ASTM D 1559-76, AASHTO T-245-90).	tie 29	22%
Test for flexural strength of concrete using simple beam with third-point loading (ASTM C 78-84, AASHTO T-97-86).	32	20%
Determine compressive strength, unconfined, of cohesive soil (ASTM D 2166, AASHTO T-208-90).	tie 33	18%
Test for bearing ratio of laboratory-compacted soils (ASTM D 1883).	tie 33	18%
Determine unconsolidated, undrained strength of cohesive soils in triaxial compression (ASTM D 2850, AASHTO T-234-85).	tie 35	16%
Test for penetration of bituminous materials (ASTM D 5-86, AASHTO T-49-89).	tie 35	16%
Determine one-dimensional consolidation properties of soils (ASTM D 2435, AASHTO T-216-83).	37	12%

Certain academic competencies are requisite for the conduct of the tests listed in the table above. These skills, primarily in Mathematics and English, are part of the normal Alabama school curriculum, and should have been mastered by the end of the eighth grade. However, they have been identified repeatedly in interviews as weaknesses in a majority of applicants, and remedial training in these areas may need to be a consideration in any training program for construction materials technicians. The following page offers a list of academic skills requisite for competency as a construction materials technician. This list is based upon a

literacy audit of the referenced AASHTO tests and standards. It is not intended as an all-inclusive list, but as a reference point for curriculum development. The academic skills are taken from the Alabama course of study: mathematics, Bulletin 1989, No. 31, and the Alabama course of study: language arts, Bulletin 1987, No. 57, which are current as of the date of this study.

Mathematics

Topics	Grade
Place value of whole and decimal numbers.	5
Rounding and estimating.	5
Operations on whole and decimal numbers.	5,6
Fractions, operations on fractions.	5,6
Integers.	5,6
Measurement concepts.	5,6
Standard measurement, applications on measurements.	5,6
Geometric figures (perpendicular, parallel, angles).	5,6
Congruence, Similarity and Symmetry.	5,6
Perimeter, area, circumference and volume.	5,6
Numerical relationships, equality relationships.	5,6
Properties of operations.	5
Statistical information.	5,6
Ratios, proportions and percents.	6
Operations on variables.	6
Demonstrate computational skills with rational numbers.	7
Develop concepts and skills associated with number and the place value system.	7
Develop an understanding of ratio, proportion and percent.	7

Extend concept of measurement to include an understanding of uses and limitations.	7
Understand and use various systems of measurement, including the metric and customary systems.	7
Develop an understanding of the vocabulary, symbols and figures of geometry.	7
Develop an understanding of mathematical algebraic expressions.	7
Demonstrate the ability to solve algebraic equations and inequalities.	7
Demonstrate an understanding of the uses of data.	7
Demonstrate an understanding of statistical measures.	7
Demonstrate an understanding of the principles of probability.	7
Develop an understanding of mathematical/algebraic expressions.	8

Language Arts

Topics	Grade
Learn basic spelling content skills.	6
Demonstrate proficiency in punctuation.	6
Demonstrate proficiency in capitalization.	6
Demonstrate proficiency in usage and grammar.	6
Demonstrate proficiency in proofreading and editing.	6
Acquire skill in using the dictionary.	7
Locate materials and read for practical purposes.	7
Locate materials in the library.	7
Read for literal and inferential comprehension.	7
Write for specific purposes and occasions.	7
Compose research reports and papers.	7

In addition to the topics listed above, the following life skills were identified during the interview process as being required for entry level employees:

1. Ability to read and follow directions.

2. Ability to read and interpret charts and graphs, and to extract and use information from these charts and graphs.

3. Attitude, a willingness to work. Several employers remarked that they did not care what skills an entry level employee possessed, a simple willingness to show up each day for work would be sufficient.

ANNEX B: Surveyor's Helper

Table B: Surveyor's Helper

Competency	Rank	Percent
Cut roadway lines, base lines, and right-of-way lines using hand or power tools.	1	100%
Perform Rod and Chain duties.	2	86%
Give back and fore sights.	3	71%
Follow oral and written instructions, including Standard Operating Procedures.	tie 4	64%
Measure distances using tape measure, chain, plumb bob, hubs, stakes, tacks, and keil.	tie 4	64%
Turn angles with transit or theodolite.	6	50%
Possess a current commercial driver's license appropriate for vehicles to be operated.	7	43%
Identify job hazards associated with the job and know appropriate safety precautions.	8	36%
Set up transit, theodolite, and level instrument.	tie 9	29%
Set blue top.	tie 9	29%
Set batter board.	tie 9	29%
Take cross sections.	tie 9	29%
Set grade and slope stakes.	tie 13	21%
Record field survey notes.	tie 13	21%
Read stadia.	tie 15	14%
Read and interpret site maps.	tie 15	14%
Read and interpret map scales and sizes.	tie 15	14%
Read and interpret field survey notes.	tie 15	14%
Turn angles with transit or theodolite.	tie 19	7%
Run a traverse.	tie 19	7%
Figure Bearings.	tie 19	7%

Plot cross sections, vertical alignments, topography, and horizontal alignment from reference book.	tie 19	7%
Obtain, analyze and record soil samples using core drill, etc.	tie 19	7%
Use Leroy set and scales to label maps.	tie 19	7%
Reduce cross section notes, using calculator and level book.	tie 19	7%

ANNEX C: Draftsman

Table C-1 combines employers' perception of needed entry level competencies for cartographic draftsman, topographic draftsman, and civil draftsman. Table C-2 follows for cartographic technician.

Table C-1: Drafting

Competency	Rank	Percent
Demonstrate basic map making skills. Use drawing instruments.	tie 1	93%
Use Leroy set and scales to label maps.	tie 1	93%
Read and interpret map scales and sizes.	3	87%
Plot cross sections, vertical alignments, topography, and horizontal alignment from reference book.	tie 4	80%
Draw contour maps.	tie 4	80%
Follow oral and written instructions, including Standard Operating Procedures.	tie 4	80%
Read and interpret field survey notes.	tie 4	80%
Plot open and closed traverse, route surveys, closed surveys, vertical and spiral curves, and conventional signs and symbols.	tie 8	74%
Reduce cross section notes, using calculator and level book.	tie 8	74%
Read and interpret aerial photographs.	tie 8	74%
Complete and file forms and records.	tie 10	67%
Calculate earthwork quantities using planimeter, calculator, constants chart, and cross section sheets to determine amount of cut and/or fill.	tie 10	67%
Figure Bearings.	12	60%
Read and interpret site maps.	tie 13	53%
Figure volume cuts and fills.	tie 13	53%

Compute project cost estimates based on unit cost and total cost, using scales, cost formula charts, maps and calculator.	15	40%
Operate a CAD system.	tie 16	33%
Check project cost estimates and compare with contract and specifications.	tie 16	33%
Lay out horizontal, vertical and spiral curves.	18	27%
Measure distances using tape measure, chain, plumb bob, hubs, stakes, tacks, and keil.	tie 19	20%
Record field survey notes.	tie 19	20%
Identify job hazards associated with the job and know appropriate safety precautions.	tie 21	13%
Balance a survey.	tie 21	13%
Run a traverse.	tie 23	7%
Possess a current commercial driver's license appropriate for vehicles to be operated.	tie 23	7%

Table C-2: Cartographic Technician

Competency	Rank	Percent
Operate a CAD system.	tie 1	89%
Read and interpret map scales and sizes.	tie 1	89%
Demonstrate basic map making skills. Use drawing instruments.	tie 3	78%
Follow oral and written instructions, including Standard Operating Procedures.	tie 3	78%
Read and interpret aerial photographs.	tie 3	78%
Use Leroy set and scales to label maps.	tie 6	67%
Draw contour maps.	tie 6	67%
Complete and file forms and records.	tie 8	56%
Read and interpret field survey notes.	tie 8	56%
Plot open and closed traverse, route surveys, closed surveys, vertical and spiral curves, and conventional signs and symbols.	tie 10	44%
Plot cross sections, vertical alignments, topography, and horizontal alignment from reference book.	tie 10	44%
Read and interpret site maps.	tie 12	33%
Figure Bearings.	tie 12	33%
Figure volume cuts and fills.	tie 12	33%
Calculate earthwork quantities using planimeter, calculator, constants chart, and cross section sheets to determine amount of cut and/or fill.	tie 12	33%
Identify job hazards associated with the job and know appropriate safety precautions.	tie 16	22%
Lay out horizontal, vertical and spiral curves.	tie 16	22%
Reduce cross section notes, using calculator and level book.	tie 16	22%
Read stadia.	tie 18	11%
Balance a survey.	tie 18	11%

Measure distances using tape measure, chain, plumb bob, hubs, stakes, tacks, and keil.	tie 18	11%
Record field survey notes.	tie 18	11%
Compute project cost estimates based on unit cost and total cost, using scales, cost formula charts, maps and calculator.	tie 18	11%
Check project cost estimates and compare with contract and specifications.	tie 18	11%

ANNEX D: Engineering Assistant

Table D: Engineering Assistant

Competency	Rank	Percent
Follow oral and written instructions, including Standard Operating Procedures.	1	95%
Figure volume cuts and fills.	tie 2	90%
Complete and file forms and records.	tie 2	90%
Reduce cross section notes, using calculator and level book.	tie 2	90%
Read and interpret map scales and sizes.	tie 2	90%
Identify job hazards associated with the job and know appropriate safety precautions.	tie 6	85%
Take cross sections.	tie 6	85%
Measure distances using tape measure, chain, plumb bob, hubs, stakes, tacks, and keil.	tie 6	85%
Read and interpret field survey notes.	tie 6	85%
Read and interpret site maps.	tie 10	75%
Plot cross sections, vertical alignments, topography, and horizontal alignment from reference book.	tie 10	75%
Inspect concrete, asphalt, steel drainage structures, roadways, grass, etc., using cylinder molds, rolometer, sleeves, thermometers, nuclear density machines, etc., to determine compliance with specifications.	tie 10	75%
Read and interpret aerial photographs.	tie 10	75%
Calculate earthwork quantities using planimeter, calculator, constants chart, and cross section sheets to determine amount of cut and/or fill.	tie 10	75%
Read stadia.	tie 15	70%
Turn angles with transit or theodolite.	tie 15	70%
Lay out horizontal, vertical and spiral curves.	tie 15	70%
Set grade and slope stakes.	tie 15	70%

Record field survey notes.	tie 15	70%
Compute project cost estimates based on unit cost and total cost, using scales, cost formula charts, maps and calculator.	tie 15	70%
Check project cost estimates and compare with contract and specifications.	tie 15	70%
Perform Rod and Chain duties.	tie 22	65%
Give back and fore sights.	tie 22	65%
Figure Bearings.	tie 22	65%
Set batter board.	tie 22	65%
Operate transit, following reference book information.	tie 22	65%
Set up transit, theodolite, and level instrument.	tie 27	60%
Run a traverse.	tie 27	60%
Plot open and closed traverse, route surveys, closed surveys, vertical and spiral curves, and conventional signs and symbols.	tie 27	60%
Cut roadway lines, base lines, and right-of-way lines using hand or power tools.	tie 27	60%
Obtain, analyze and record soil samples using core drill, etc.	31	55%
Balance a survey.	32	45%
Possess a current commercial driver's license appropriate for vehicles to be operated.	33	35%
Demonstrate basic map making skills. Use drawing instruments.	tie 34	30%
Use Leroy set and scales to label maps.	tie 34	30%
Draw contour maps.	36	25%
Operate a CAD system.	37	15%

ANNEX E: Earthmoving Heavy Equipment Operator

Heavy Equipment Operator, Earthmoving: Table E-1 combines employer's perception of needed entry level competencies for bulldozer operators, tractor-backhoe operators, motor grader operators, self propelled compaction equipment operators, power shovel operators, and scraper operators. These job areas will be addressed separately in tables E-2 through E-7.

Table E-1: Combined Earthmoving Heavy Equipment Operator

Competency	Rank	Percent
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 1	94%
Demonstrate ability to understand and follow standard hand signals.	tie 1	94%
Operate and maintain safety devices on equipment.	tie 1	94%
Perform equipment shut down in accordance with operator's manual.	tie 1	94%
Understand and describe functions of equipment controls.	tie 5	90%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 5	90%
Identify and wear personal safety equipment for the job.	tie 7	88%
Know how to use different types of fire extinguishers.	tie 7	88%
Read and understand operator's manual for equipment to be used.	tie 7	88%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 7	88%
Perform pre-startup inspection in accordance with the operator's manual.	tie 7	88%
Demonstrate ability to control equipment in emergency situations.	12	84%

Perform routine troubleshooting in accordance with the operator's manual.	tie 13	82%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 13	82%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 13	82%
Operate the machine, as directed, within its design capabilities and specifications.	tie 13	82%
Detect incorrect operation of the equipment by sound or function.	17	80%
Work safely with other equipment in close areas.	18	75%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	19	73%
Understand and describe machine capability, specifications, and normal operating procedures.	20	69%
Load and tie down equipment on transport vehicle.	tie 21	58%
Remove tie downs and unload equipment from transport vehicle.	tie 21	58%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	23	55%
Keep and maintain equipment records.	24	53%
Possess appropriate commercial driver's license.	25	49%
Demonstrate knowledge of the principles of hydraulics.	26	45%
Demonstrate knowledge of the power flow from engine through power train.	27	39%

Table E-2: Bulldozer Operator

Competency	Rank	Percent
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 1	100%
Demonstrate ability to understand and follow standard hand signals.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Identify and wear personal safety equipment for the job.	tie 5	94%
Know how to use different types of fire extinguishers.	tie 5	94%
Read and understand operator's manual for equipment to be used.	tie 5	94%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 5	94%
Understand and describe functions of equipment controls.	tie 5	94%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 5	94%
Perform pre-startup inspection in accordance with the operator's manual.	tie 5	94%
Demonstrate ability to control equipment in emergency situations.	tie 12	88%
Perform routine troubleshooting in accordance with the operator's manual.	tie 12	88%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 12	88%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 12	88%
Operate the machine, as directed, within its design capabilities and specifications.	tie 12	88%
Detect incorrect operation of the equipment by sound or function.	17	82%

Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 18	76%
Work safely with other equipment in close areas.	tie 18	76%
Understand and describe machine capability, specifications, and normal operating procedures.	20	71%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 21	59%
Keep and maintain equipment records.	tie 21	59%
Load and tie down equipment on transport vehicle.	tie 21	59%
Remove tie downs and unload equipment from transport vehicle.	tie 21	59%
Possess appropriate commercial driver's license.	25	53%
Demonstrate knowledge of the principles of hydraulics.	26	47%
Demonstrate knowledge of the power flow from engine through power train.	27	41%

Table E-3: Tractor-Back Hoe

Competency	Rank	Percent
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 1	100%
Understand and describe functions of equipment controls.	tie 1	100%
Demonstrate ability to understand and follow standard hand signals.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Identify and wear personal safety equipment for the job.	tie 7	94%
Know how to use different types of fire extinguishers.	tie 7	94%
Read and understand operator's manual for equipment to be used.	tie 7	94%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 7	94%
Demonstrate ability to control equipment in emergency situations.	tie 7	94%
Perform pre-startup inspection in accordance with the operator's manual.	tie 7	94%
Detect incorrect operation of the equipment by sound or function.	tie 13	88%
Perform routine troubleshooting in accordance with the operator's manual.	tie 13	88%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 13	88%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 13	88%
Operate the machine, as directed, within its design capabilities and specifications.	tie 13	88%

Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 18	81%
Work safely with other equipment in close areas.	tie 18	81%
Understand and describe machine capability, specifications, and normal operating procedures.	20	75%
Load and tie down equipment on transport vehicle.	tie 21	69%
Remove tie downs and unload equipment from transport vehicle.	tie 21	69%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 23	56%
Keep and maintain equipment records.	tie 23	56%
Demonstrate knowledge of the principles of hydraulics.	tie 25	50%
Possess appropriate commercial driver's license.	tie 25	50%
Demonstrate knowledge of the power flow from engine through power train.	27	44%

Table E-4: Motor Grader

Competency	Rank	Percent
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 1	100%
Demonstrate ability to understand and follow standard hand signals.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Identify and wear personal safety equipment for the job.	tie 5	94%
Know how to use different types of fire extinguishers.	tie 5	94%
Read and understand operator's manual for equipment to be used.	tie 5	94%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 5	94%
Understand and describe functions of equipment controls.	tie 5	94%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 5	94%
Perform pre-startup inspection in accordance with the operator's manual.	tie 5	94%
Demonstrate ability to control equipment in emergency situations.	tie 12	88%
Perform routine troubleshooting in accordance with the operator's manual.	tie 12	88%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 12	88%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 12	88%
Operate the machine, as directed, within its design capabilities and specifications.	tie 12	88%
Detect incorrect operation of the equipment by sound or function.	17	82%

Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 18	76%
Work safely with other equipment in close areas.	tie 18	76%
Understand and describe machine capability, specifications, and normal operating procedures.	20	71%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 21	59%
Keep and maintain equipment records.	tie 21	59%
Load and tie down equipment on transport vehicle.	tie 21	59%
Remove tie downs and unload equipment from transport vehicle.	tie 21	59%
Possess appropriate commercial driver's license.	25	53%
Demonstrate knowledge of the principles of hydraulics.	26	47%
Demonstrate knowledge of the power flow from engine through power train.	27	41%

Table E-5: Self Propelled Compaction

Competency	Rank	Percent
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 1	100%
Demonstrate ability to understand and follow standard hand signals.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Identify and wear personal safety equipment for the job.	tie 5	94%
Know how to use different types of fire extinguishers.	tie 5	94%
Read and understand operator's manual for equipment to be used.	tie 5	94%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 5	94%
Understand and describe functions of equipment controls.	tie 5	94%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 5	94%
Perform pre-startup inspection in accordance with the operator's manual.	tie 5	94%
Demonstrate ability to control equipment in emergency situations.	tie 12	88%
Perform routine troubleshooting in accordance with the operator's manual.	tie 12	88%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 12	88%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 12	88%
Operate the machine, as directed, within its design capabilities and specifications.	tie 12	88%
Detect incorrect operation of the equipment by sound or function.	17	82%

Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 18	76%
Work safely with other equipment in close areas.	tie 18	76%
Understand and describe machine capability, specifications, and normal operating procedures.	20	71%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 21	59%
Keep and maintain equipment records.	tie 21	59%
Load and tie down equipment on transport vehicle.	tie 21	59%
Remove tie downs and unload equipment from transport vehicle.	tie 21	59%
Possess appropriate commercial driver's license.	25	53%
Demonstrate knowledge of the principles of hydraulics.	26	47%
Demonstrate knowledge of the power flow from engine through power train.	27	41%

Table E-6: Power Shovel

Competency	Rank	Percent
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 1	100%
Understand and describe functions of equipment controls.	tie 1	100%
Demonstrate ability to understand and follow standard hand signals.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Identify and wear personal safety equipment for the job.	tie 7	93%
Know how to use different types of fire extinguishers.	tie 7	93%
Read and understand operator's manual for equipment to be used.	tie 7	93%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 7	93%
Demonstrate ability to control equipment in emergency situations.	tie 7	93%
Perform pre-startup inspection in accordance with the operator's manual.	tie 7	93%
Detect incorrect operation of the equipment by sound or function.	tie 7	93%
Perform routine troubleshooting in accordance with the operator's manual.	tie 14	86%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 14	86%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 14	86%
Work safely with other equipment in close areas.	tie 14	86%

Operate the machine, as directed, within its design capabilities and specifications.	tie 14	86%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 19	79%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 19	79%
Load and tie down equipment on transport vehicle.	tie 21	64%
Remove tie downs and unload equipment from transport vehicle.	tie 21	64%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	23	57%
Demonstrate knowledge of the principles of hydraulics.	tie 24	50%
Keep and maintain equipment records.	tie 24	50%
Possess appropriate commercial driver's license.	tie 24	50%
Demonstrate knowledge of the power flow from engine through power train.	27	44%

Table E-7: Scraper

Competency	Rank	Percent
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 1	100%
Demonstrate ability to understand and follow standard hand signals.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Identify and wear personal safety equipment for the job.	tie 5	93%
Know how to use different types of fire extinguishers.	tie 5	93%
Read and understand operator's manual for equipment to be used.	tie 5	93%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 5	93%
Understand and describe functions of equipment controls.	tie 5	93%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 5	93%
Perform pre-startup inspection in accordance with the operator's manual.	tie 5	93%
Demonstrate ability to control equipment in emergency situations.	tie 12	87%
Detect incorrect operation of the equipment by sound or function.	tie 12	87%
Perform routine troubleshooting in accordance with the operator's manual.	tie 12	87%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 12	87%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 12	87%
Operate the machine, as directed, within its design capabilities and specifications.	tie 12	87%

Work safely with other equipment in close areas.	18	80%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 19	73%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 19	73%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 21	60%
Load and tie down equipment on transport vehicle.	tie 21	60%
Remove tie downs and unload equipment from transport vehicle.	tie 21	60%
Keep and maintain equipment records.	tie 24	53%
Possess appropriate commercial driver's license.	tie 24	53%
Demonstrate knowledge of the principles of hydraulics.	26	47%
Demonstrate knowledge of the power flow from engine through power train.	27	40%

ANNEX F: Asphalt Equipment Operator

HEAVY EQUIPMENT (ASPHALT): Table F-1 includes replies from all asphalt specialties, combined into one table. The information could be used to examine which competencies are most commonly desired of entry level employees across the spectrum of asphalt related job categories. Tables F-2 through F-6 address the job specialties of Asphalt Laydown Machine Operator, Self Propelled Asphalt Spreader Operator, Asphalt Recycling Machine Operator, Asphalt Distributor Operator, Pugmill Operator, and Asphalt Plant Operator.

Table F-1: Combined Asphalt Equipment Operator

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	1	60%
Operate and maintain safety devices on equipment.	2	56%
Know how to use different types of fire extinguishers.	3	55%
Perform equipment shut down in accordance with operator's manual.	tie 4	53%
Read and understand operator's manual for equipment to be used.	tie 4	53%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 6	51%
Perform pre-startup inspection in accordance with the operator's manual.	tie 6	51%
Operate the machine, as directed, within its design capabilities and specifications.	tie 6	51%
Understand and describe functions of equipment controls.	9	49%
Demonstrate ability to control equipment in emergency situations.	tie 10	47%
Demonstrate ability to understand and follow standard hand signals.	tie 10	47%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 10	47%

Identify job hazards associated with equipment, hydraulic or fuel systems.	13	46%
Work safely in close areas other equipment.	14	44%
Perform clean up of equipment in accordance with manufacturer's specifications.	15	41%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 16	40%
Detect incorrect operation of the equipment by sound or function.	tie 16	40%
Perform routine trouble shooting in accordance with the operator's manual.	18	33%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 19	30%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 19	30%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 19	30%
Load and tie down equipment on transport vehicle.	tie 22	21%
Remove tie downs and unload equipment from transport vehicle.	tie 22	21%
Keep and maintain equipment records.	tie 22	21%
Demonstrate knowledge of the principles of hydraulics.	tie 25	18%
Determine whether surface to be spread is sufficiently clean and dry.	tie 25	18%
Demonstrate knowledge of the components of an asphalt plant, including oil heating systems.	tie 27	12%
Demonstrate knowledge of the process of preparing an asphalt plant for operation and/or shut down.	tie 27	12%
Demonstrate knowledge of the power flow from engine through power train.	29	9%

Table F-2: Asphalt Laydown Machine

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	tie 1	61%
Know how to use different types of fire extinguishers.	tie 1	61%
Read and understand operator's manual for equipment to be used.	tie 1	61%
Understand and describe functions of equipment controls.	tie 1	61%
Demonstrate ability to control equipment in emergency situations.	tie 1	61%
Demonstrate ability to understand and follow standard hand signals.	tie 1	61%
Operate and maintain safety devices on equipment.	tie 1	61%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 1	61%
Perform pre-startup inspection in accordance with the operator's manual.	tie 1	61%
Perform equipment shut down in accordance with operator's manual.	tie 1	61%
Operate the machine, as directed, within its design capabilities and specifications.	tie 1	61%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 12	54%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 12	54%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 12	54%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 15	46%
Detect incorrect operation of the equipment by sound or function.	tie 15	46%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 15	46%

Work safely in close areas with other equipment.	tie 15	46%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 19	38%
Perform routine troubleshooting in accordance with the operator's manual.	tie 19	38%
Demonstrate knowledge of the principles of hydraulics.	tie 21	31%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 21	31%
Load and tie down equipment on transport vehicle.	tie 21	31%
Remove tie downs and unload equipment from transport vehicle.	tie 21	31%
Determine whether surface to be spread is sufficiently clean and dry.	tie 21	31%
Keep and maintain equipment records.	26	23%
Demonstrate knowledge of the power flow from engine through power train.	tie 27	8%
Demonstrate knowledge of the components of an asphalt plant, including oil heating systems.	tie 27	8%
Demonstrate knowledge of the process of preparing an asphalt plant for operation and/or shut down.	tie 27	8%

Table F-3: Self Propelled Asphalt Spreader

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	tie 1	100%
Know how to use different types of fire extinguishers.	tie 1	100%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 1	100%
Perform pre-startup inspection in accordance with the operator's manual.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Operate the machine, as directed, within its design capabilities and specifications.	tie 1	100%
Read and understand operator's manual for equipment to be used.	tie 7	90%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 7	90%
Operate and maintain safety devices on equipment.	tie 7	90%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 10	80%
Understand and describe functions of equipment controls.	tie 10	80%
Demonstrate ability to control equipment in emergency situations.	tie 10	80%
Demonstrate ability to understand and follow standard hand signals.	tie 10	80%
Detect incorrect operation of the equipment by sound or function.	tie 10	80%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 10	80%
Work safely in close areas other equipment.	tie 10	80%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 17	70%

Perform routine troubleshooting in accordance with the operator's manual.	tie 17	70%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 19	60%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 19	60%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 19	60%
Load and tie down equipment on transport vehicle.	tie 19	60%
Remove tie downs and unload equipment from transport vehicle.	tie 19	60%
Demonstrate knowledge of the principles of hydraulics.	tie 24	50%
Keep and maintain equipment records.	tie 24	50%
Determine whether surface to be spread is sufficiently clean and dry.	tie 24	50%
Demonstrate knowledge of the power flow from engine through power train.	27	20%
Demonstrate knowledge of the components of an asphalt plant, including oil heating systems.	tie 28	10%
Demonstrate knowledge of the process of preparing an asphalt plant for operation and/or shut down.	tie 28	10%

Table F-4: Asphalt Recycling Machine

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	1	100%
Know how to use different types of fire extinguishers.	tie 2	80%
Operate and maintain safety devices on equipment.	tie 2	80%
Read and understand operator's manual for equipment to be used.	tie 4	60%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 4	60%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 4	60%
Understand and describe functions of equipment controls.	tie 4	60%
Demonstrate ability to control equipment in emergency situations.	tie 4	60%
Demonstrate ability to understand and follow standard hand signals.	tie 4	60%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 4	60%
Perform pre-startup inspection in accordance with the operator's manual.	tie 4	60%
Perform equipment shut down in accordance with operator's manual.	tie 4	60%
Work safely in close areas other equipment.	tie 4	60%
Operate the machine, as directed, within its design capabilities and specifications.	tie 4	60%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 15	40%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 15	40%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 15	40%

Detect incorrect operation of the equipment by sound or function.	tie 15	40%
Perform routine troubleshooting in accordance with the operator's manual.	tie 15	40%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 15	40%
Demonstrate knowledge of the principles of hydraulics.	tie 21	20%
Demonstrate knowledge of the power flow from engine through power train.	tie 21	20%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 21	20%
Load and tie down equipment on transport vehicle.	tie 21	20%
Remove tie downs and unload equipment from transport vehicle.	tie 21	20%

Table F-5: Asphalt Distributor

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	tie 1	100%
Know how to use different types of fire extinguishers.	tie 1	100%
Read and understand operator's manual for equipment to be used.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform pre-startup inspection in accordance with the operator's manual.	tie 5	92%
Perform equipment shut down in accordance with operator's manual.	tie 5	92%
Operate the machine, as directed, within its design capabilities and specifications.	tie 5	92%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 8	85%
Understand and describe functions of equipment controls.	tie 8	85%
Demonstrate ability to understand and follow standard hand signals.	tie 8	85%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 8	85%
Work safely in close areas other equipment.	tie 8	85%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 13	77%
Demonstrate ability to control equipment in emergency situations.	tie 13	77%
Operate and maintain safety devices on equipment.	tie 13	77%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 13	77%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 17	69%
Detect incorrect operation of the equipment by sound or function.	tie 17	69%

Perform routine troubleshooting in accordance with the operator's manual.	19	62%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 20	46%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 20	46%
Keep and maintain equipment records.	tie 22	38%
Determine whether surface to be spread is sufficiently clean and dry.	tie 22	38%
Load and tie down equipment on transport vehicle.	tie 24	31%
Remove tie downs and unload equipment from transport vehicle.	tie 24	31%
Demonstrate knowledge of the principles of hydraulics.	tie 26	15%
Demonstrate knowledge of the power flow from engine through power train.	tie 26	15%

Table F-6: Pugmill

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	1	80%
Operate and maintain safety devices on equipment.	tie 2	60%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 2	60%
Perform pre-startup inspection in accordance with the operator's manual.	tie 2	60%
Detect incorrect operation of the equipment by sound or function.	tie 2	60%
Perform equipment shut down in accordance with operator's manual.	tie 2	60%
Work safely in close areas other equipment.	tie 2	60%
Operate the machine, as directed, within its design capabilities and specifications.	tie 2	60%
Know how to use different types of fire extinguishers.	tie 9	40%
Read and understand operator's manual for equipment to be used.	tie 9	40%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 9	40%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 9	40%
Understand and describe functions of equipment controls.	tie 9	40%
Demonstrate ability to control equipment in emergency situations.	tie 9	40%
Demonstrate ability to understand and follow standard hand signals.	tie 9	40%
Perform routine troubleshooting in accordance with the operator's manual.	tie 9	40%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 9	40%

Perform clean up of equipment in accordance with manufacturer's specifications.	tie 9	40%
Understand and describe machine capability, specifications, normal operating procedures.	tie 19	20%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 19	20%
Demonstrate knowledge of the principles of hydraulics.	tie 19	20%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 19	20%
Keep and maintain equipment records.	tie 19	20%
Demonstrate knowledge of the components of an asphalt plant, including oil heating systems.	tie 19	20%
Demonstrate knowledge of the process of preparing an asphalt plant for operation and/or shut down.	tie 19	20%

Table F-7: Asphalt Plant

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Know how to use different types of fire extinguishers.	tie 3	86%
Read and understand operator's manual for equipment to be used.	tie 3	86%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 3	86%
Understand and describe functions of equipment controls.	tie 3	86%
Demonstrate ability to control equipment in emergency situations.	tie 3	86%
Demonstrate knowledge of the components of an asphalt plant, including oil heating systems.	tie 3	86%
Demonstrate knowledge of the process of preparing an asphalt plant for operation and/or shut down.	tie 3	86%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 10	71%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 10	71%
Demonstrate ability to understand and follow standard hand signals.	tie 10	71%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 10	71%
Perform equipment shut down in accordance with operator's manual.	tie 10	71%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 15	57%
Perform pre-startup inspection in accordance with the operator's manual.	tie 15	57%

Perform clean up of equipment in accordance with manufacturer's specifications.	tie 15	57%
Operate the machine, as directed, within its design capabilities and specifications.	tie 15	57%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 19	43%
Detect incorrect operation of the equipment by sound or function.	tie 19	43%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 19	43%
Work safely in close areas other equipment.	tie 19	43%
Perform routine troubleshooting in accordance with the operator's manual.	tie 23	29%
Keep and maintain equipment records.	tie 23	29%
Demonstrate knowledge of the principles of hydraulics.	tie 25	14%
Demonstrate knowledge of the power flow from engine through power train.	tie 25	14%
Load and tie down equipment on transport vehicle.	tie 25	14%
Remove tie downs and unload equipment from transport vehicle.	tie 25	14%

ANNEX G: Heavy Equipment Operator - Other

Table G-1 combines employer's perception of needed entry level competencies for Cherry Picker (Hi-Lift) Operator, Forklift Operator, Tractor Crane Operator, Truck Driver, Striping Equipment Operator, Vacuum Sweeper Operator, and Mud Jack Operator. Specific job areas will be addressed separately in Tables G-2 through G-6, except for Vacuum Sweeper Operator and Mud Jack Operator, which had insufficient responses to tabulate on a stand alone basis.

Table G-1: Heavy Equipment Operator - Other

Competency	Rank	Percent
Operate and maintain safety devices on equipment.	1	53%
Identify and wear personal safety equipment for the job.	2	52%
Demonstrate ability to understand and follow standard hand signals.	tie 3	51%
Perform equipment shut down in accordance with operator's manual.	tie 3	51%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 5	50%
Detect incorrect operation of the equipment by sound or function.	tie 5	50%
Operate the machine, as directed, within its design capabilities and specifications.	tie 5	50%
Read and understand operator's manual for equipment to be used.	tie 8	49%
Perform pre-startup inspection in accordance with the operator's manual.	tie 8	49%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 8	49%
Demonstrate ability to control equipment in emergency situations.	tie 11	48%

Work safely with other equipment in close areas.	tie 11	48%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 13	47%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 13	47%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 15	46%
Understand and describe functions of equipment controls.	tie 15	46%
Know how to use different types of fire extinguishers.	tie 17	43%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 17	43%
Demonstrate knowledge of the principles of hydraulics.	tie 19	41%
Keep and maintain equipment records.	tie 19	41%
Remove tie downs and unload equipment from transport vehicle.	21	39%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 22	38%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 22	38%
Demonstrate knowledge of the power flow from engine through power train.	tie 24	37%
Perform routine troubleshooting in accordance with the operator's manual.	tie 24	37%
Load and tie down equipment on transport vehicle.	26	36%
Possess appropriate commercial driver's license.	27	33%

Table G-2: Cherry Picker (Hi-Lift)

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	tie 1	100%
Read and understand operator's manual for equipment to be used.	tie 1	100%
Understand and describe functions of equipment controls.	tie 1	100%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 1	100%
Demonstrate ability to understand and follow standard hand signals.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 1	100%
Demonstrate knowledge of the principles of hydraulics.	tie 1	100%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 1	100%
Perform pre-startup inspection in accordance with the operator's manual.	tie 1	100%
Detect incorrect operation of the equipment by sound or function.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 1	100%
Operate the machine, as directed, within its design capabilities and specifications.	tie 1	100%
Know how to use different types of fire extinguishers.	tie 15	88%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 15	88%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 15	88%

Demonstrate ability to control equipment in emergency situations.	tie 15	88%
Demonstrate knowledge of the power flow from engine through power train.	tie 15	88%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 15	88%
Perform routine troubleshooting in accordance with the operator's manual.	tie 15	88%
Keep and maintain equipment records.	tie 15	88%
Work safely with other equipment in close areas.	tie 15	88%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 24	63%
Load and tie down equipment on transport vehicle.	tie 24	63%
Remove tie downs and unload equipment from transport vehicle.	tie 24	63%
Possess appropriate commercial driver's license.	27	50%

Table G-3: Forklift

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	tie 1	90%
Read and understand operator's manual for equipment to be used.	tie 1	90%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 1	90%
Operate and maintain safety devices on equipment.	tie 1	90%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 1	90%
Perform pre-startup inspection in accordance with the operator's manual.	tie 1	90%
Detect incorrect operation of the equipment by sound or function.	tie 1	90%
Perform equipment shut down in accordance with operator's manual.	tie 1	90%
Operate the machine, as directed, within its design capabilities and specifications.	tie 1	90%
Know how to use different types of fire extinguishers.	tie 10	80%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 10	80%
Understand and describe functions of equipment controls.	tie 10	80%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 10	80%
Demonstrate ability to control equipment in emergency situations.	tie 10	80%
Demonstrate ability to understand and follow standard hand signals.	tie 10	80%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 10	80%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 10	80%

Work safely with other equipment in close areas.	tie 10	80%
Demonstrate knowledge of the principles of hydraulics.	tie 19	70%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 19	70%
Keep and maintain equipment records.	tie 19	70%
Demonstrate knowledge of the power flow from engine through power train.	tie 22	60%
Perform routine troubleshooting in accordance with the operator's manual.	tie 22	60%
Load and tie down equipment on transport vehicle.	tie 22	60%
Remove tie downs and unload equipment from transport vehicle.	tie 22	60%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	26	50%
Possess appropriate commercial driver's license.	27	30%

Table G-4: Tractor Crane

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	tie 1	100%
Read and understand operator's manual for equipment to be used.	tie 1	100%
Demonstrate ability to understand and follow standard hand signals.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 1	100%
Perform pre-startup inspection in accordance with the operator's manual.	tie 1	100%
Detect incorrect operation of the equipment by sound or function.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 1	100%
Operate the machine, as directed, within its design capabilities and specifications.	tie 1	100%
Know how to use different types of fire extinguishers.	tie 11	89%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 11	89%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 11	89%
Understand and describe functions of equipment controls.	tie 11	89%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 11	89%
Demonstrate ability to control equipment in emergency situations.	tie 11	89%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 11	89%

Keep and maintain equipment records.	tie 11	89%
Work safely with other equipment in close areas.	tie 11	89%
Demonstrate knowledge of the principles of hydraulics.	tie 20	78%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 20	78%
Demonstrate knowledge of the power flow from engine through power train.	tie 22	67%
Perform routine troubleshooting in accordance with the operator's manual.	tie 22	67%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 22	67%
Load and tie down equipment on transport vehicle.	tie 25	56%
Remove tie downs and unload equipment from transport vehicle.	tie 25	56%
Possess appropriate commercial driver's license.	tie 25	56%

Table G-5: Truck Driver

Competency	Rank	Percent
Demonstrate ability to understand and follow standard hand signals.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 1	100%
Perform pre-startup inspection in accordance with the operator's manual.	tie 1	100%
Detect incorrect operation of the equipment by sound or function.	tie 1	100%
Perform equipment shut down in accordance with operator's manual.	tie 1	100%
Identify and wear personal safety equipment for the job.	tie 7	95%
Read and understand operator's manual for equipment to be used.	tie 7	95%
Operate the machine, as directed, within its design capabilities and specifications.	tie 7	95%
Possess appropriate commercial driver's license.	tie 7	95%
Know how to use different types of fire extinguishers.	tie 11	89%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 11	89%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 11	89%
Understand and describe functions of equipment controls.	tie 11	89%
Demonstrate ability to control equipment in emergency situations.	tie 11	89%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 11	89%
Work safely with other equipment in close areas.	tie 11	89%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 18	84%

Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 18	84%
Load and tie down equipment on transport vehicle.	tie 18	84%
Remove tie downs and unload equipment from transport vehicle.	tie 18	84%
Demonstrate knowledge of the principles of hydraulics.	tie 22	74%
Keep and maintain equipment records.	tie 22	74%
Demonstrate knowledge of the power flow from engine through power train.	tie 24	68%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 24	68%
Perform routine troubleshooting in accordance with the operator's manual.	26	63%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	27	58%

Table G-6: Striping Equipment

Competency	Rank	Percent
Identify and wear personal safety equipment for the job.	tie 1	100%
Operate and maintain safety devices on equipment.	tie 1	100%
Perform routine service and preventive maintenance procedures in accordance with operator's manual.	tie 1	100%
Identify job hazards associated with ground personnel, other equipment, or job sites.	tie 4	80%
Demonstrate ability to control equipment in emergency situations.	tie 4	80%
Demonstrate ability to understand and follow standard hand signals.	tie 4	80%
Perform equipment shut down in accordance with operator's manual.	tie 4	80%
Perform clean up of equipment in accordance with manufacturer's specifications.	tie 4	80%
Work safely with other equipment in close areas.	tie 4	80%
Read and understand operator's manual for equipment to be used.	tie 10	60%
Identify job hazards associated with equipment, hydraulic or fuel systems.	tie 10	60%
Understand and describe machine capability, specifications, and normal operating procedures.	tie 10	60%
Demonstrate knowledge of the function and importance of heavy equipment filtering systems.	tie 10	60%
Perform equipment walk around and visual inspection in accordance with the operator's manual.	tie 10	60%
Perform pre-startup inspection in accordance with the operator's manual.	tie 10	60%
Detect incorrect operation of the equipment by sound or function.	tie 10	60%
Perform routine troubleshooting in accordance with the operator's manual.	tie 10	60%

Keep and maintain equipment records.	tie 10	60%
Remove tie downs and unload equipment from transport vehicle.	tie 10	60%
Operate the machine, as directed, within its design capabilities and specifications.	tie 10	60%
Know how to use different types of fire extinguishers.	tie 21	40%
Understand and describe functions of equipment controls.	tie 21	40%
Demonstrate knowledge of the principles of operation of diesel and gasoline engines.	tie 21	40%
Demonstrate knowledge of the principles of hydraulics.	tie 21	40%
Demonstrate knowledge of the power flow from engine through power train.	tie 21	40%
Load and tie down equipment on transport vehicle.	tie 21	40%
Possess appropriate commercial driver's license.	tie 21	40%