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16. Abstract

The objective of this study was the development of a battery of tests for predicting an applicants' potential for completing engineer training and performing well as a locomotive engineer. In preparation for developing this battery, a job analysis was conducted. The job analysis for the locomotive engineer's job involved seven steps: 1) review of existing research on the locomotive engineer job to develop a task list; 2) a site visit to one of the participating railroads, Union Pacific (UP); 3) review and revision of the tasks by UP job experts; 4) ratings of the tasks by UP engineers; 5) identification of the required knowledges, skills and abilities (KSAs) by UP engineers; 6) review of the task list by eight additional participating railroads, (Amtrak; Burlington Northern; Conrail; Santa Fe; Bessemer and Lake Erie; Elgin, Joliet, and Eastern; Union, and Duluth, Missabe, and Iron Range); and 7) review of the KSAs by the first four railroads. This thorough and comprehensive job analysis procedure resulted in a list of critical KSA job requirements that were considered appropriate for subsequent test development. These requirements included reading, memorizing, understanding oral instructions, logical reasoning, focusing attention, and attention to detail.

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16. Abstract (continued)

Test development proceeded directly from the job analysis results and the tests were designed to be as practical as possible, to facilitate their use by the railroads. The following six ability tests were developed to measure the important KSA requirements for the selection and promotion of locomotive engineers: Memory, Reading Comprehension, Perception (measuring attention to detail), Listening, Logical Reasoning, and Dichotic Listening (measuring focusing attention).

Internal consistency analyses on the tests indicated that they had high reliability; coefficient alpha estimates ranged from .77 to .98. Furthermore, the tests correlated with one another in a meaningful, interpretable pattern. These analyses further substantiated the technical adequacy of the test battery.

The next step in the project involved determining if the tests predict engineers' performance. This step is called validation. Validation is demonstrated by a statistical relationship between tests scores and engineer performance. Two validation studies were undertaken.

The purpose of the first study was to see if the tests predicted job performance. In this study, a sample of engineers from 11 participating companies took the tests and were rated on their job performance, using a specially developed rating form. No significant relationships were found between the tests and the performance ratings.

In the second study, the test battery was studied as a predictor of engineer training. Statistical analyses were performed on data from engineer trainees to assess the relationship between the six selection tests, written job knowledge tests, and scores on the three simulator runs. The major results are summarized as follows: 1) Scores on the selection tests were not significantly related to simulator performance; 2) Scores on three of the cognitive ability tests - Reading, Logical Reasoning, and Dichotic Listening - were significantly related to performance on the two job knowledge exams; and 3) Performance on the job knowledge tests were significantly correlated with simulator performance.

A step-wise multiple regression indicated that the Reading Test and the Dichotic Listening Test efficiently predicted the written training tests. The results of these analyses show that these two tests can be used to identify applicants likely to pass engineer training.

EXECUTIVE SUMMARY

The railroad industry faces legal, economic, and public pressures to improve the quality and safety of train services. One way of doing this is by improving the selection of its operating personnel, especially engineers. The Federal Railroad Administration supported this study to develop and validate a battery of selection tests that can be used for the identification of internal and external candidates for the engineer's job. The purpose of the project is to provide tests which the railroads can use to select engineer candidates who are capable of learning and later, performing the job successfully.

The foundation for building selection tests consists of defining the job tasks and identifying the skills and abilities which are required to perform these tasks. A systematic method used to identify these job tasks and the knowledge, skills, abilities, and other personal characteristics (KSAs) required for effective job performance is job analysis.

The job analysis undertaken in this project was complex since several railroads joined the project after the job analysis was completed in the initially participating railroad, Union Pacific (UP) Railroad. An engineer task list was developed using information gathered from a literature review, observations of job performance, and interviews with UP job experts (engineers, road foremen, and trainers). The tasks were then rated by UP engineers to identify those which were important and be-consuming. As the next step in the job analysis, the KSA requirements of the engineer job were determined for UP engineers. Other railroads (Amtrak; Burlington Northern; Conrail; Santa Fe; Bessemer and Lake Erie; Elgin, Joliet and Eastern; Union; and Duluth, Missabe and Iron Range) then joined the study. Since the study was intended for industry-wide use, we decided to expand the information about the engineer job by collecting additional job analytic information. Task ratings were collected from all of these eight railroads to determine the degree that the important UP tasks were also rated as important in the other railroads. Similarly, KSA ratings were collected from job experts in the first four railroads and compared to the KSA ratings from UP. The results of the job analysis indicated that despite differences in railroad rules, conditions and size, the tasks performed and the KSAs required for the important engineer job tasks were consistent across the participating railroads.

Six tests were then developed to assess important KSAs identified in the job analysis. These tests included: Memory, Reading, Perception (measuring attention to detail), Understanding Oral Instructions, Logical Reasoning, and Dichotic Listening (a measure of the ability to focus attention). The next step in the project was validation. Validation refers to the collection of evidence that the test is able to predict how well a job candidate will perform in training or on the job. The evidence used to support test validity in personnel research is the demonstration of a useful relationship between test scores and one or more measures of job or training performance. In this project, the engineer test battery was validated in two studies. The purpose of the first study was to determine if the tests in the battery predict job performance, specifically supervisor ratings of engineer performance. The purpose of the second study was to determine if the test battery predicts training performance.

In the first study, a group of 141 engineers in 11 railroads were given the tests in the battery and were evaluated by their road foremen, using a specially developed observational rating form. The analysis of the validation data was through the examination of the corrections between the tests in the battery and the scores on the observational rating scale. None of the correlations were statistically significant; i.e., the tests were not effective predictors of the job performance ratings.

Potential explanations of these low correlations could focus on the tests, the job performance ratings, or both. Examination of the tests revealed that: they measured important KSA requirements of the engineer job; they capture the abilities they were developed to measure; and they displayed adequate test reliability. Furthermore, much previous research attests to the efficacy of these types of tests for predicting job performance across a wide variety of jobs and organizations. Hence, it seems reasonable to expect that these tests would predict job performance for locomotive engineers. Consideration of the job performance measure suggests several potential explanations for the low correlations. A small study demonstrated the modest reliability of the ratings over time, suggesting that differences in raters, railroads, and the runs could affect these ratings. In addition, the supervisor ratings displayed low variability. The limitations in the supervisor ratings were a likely cause of the low correlations between the selection tests and the job performance measure in this study.

The purpose of the second validation study was to determine if the test battery predicts training performance. In this study, a group of Burlington Northern engineer trainees took the tests in the battery during the classroom phase of After approximately 10 weeks of operating trains under the supervision of qu ed engineers, the trainees were given tests to evaluate their job knowledge and skill. These training tests were two written engineer knowledge tests (one on operating rules and a second on air break rules) and three runs on a simulator. The knowledge test scores, along with the selection test scores, were available for 123 engineer trainees; and simulator scores were available for 114 trainees. The correlations between the selection tests and the simulator runs were not significant, while the correlations between three of the selection tests (Reading Comprehension, Logical Reasoning, and Dichotic Listening) and each of the two job knowledge tests were statistically significant. In addition, the job knowledge tests were significantly correlated with the sum of the simulator runs. Multiple regression analysis indicated that two of the tests (Reading Comprehension and Dichotic Listening) efficiently predicted the job knowledge test scores.

Based on these findings, we conclude that the selection tests predict performance on the job knowledge tests and that performance on job knowledge tests predict performance on the simulator. However, there is no direct relationship between test scores on the selection tests and performance on the simulator. The results of Study 2 are consistent with the results of prior research indicating that cognitive ability tests are critical for successful training. Hunter (1983) sheds insight on the links between cognitive ability tests (like those in the selection battery), training performance, and job performance. Hunter's analysis of 14 validation studies indicates that cognitive abilities influence the extent to which an individual masters the knowledge required for job performance. Job knowledge then mediates the relationship between cognitive abilities and job performance. Models of Ackerman (1992) and Fleishman (1967, 1972, 1975) also can help us understand these findings. Their research suggests that cognitive ability tests predict the learning phase of job performance but are less predictive of the skilled phase of job performance for jobs which are overlearned and relatively routine (like the engineer job).

What implications do these results have for the usefulness of the selection tests for selecting locomotive engineers? Three of the tests--Reading, Logical Reasoning, and Dichotic Listening predict scores on job knowledge tests. Two of these tests--Reading and Dichotic Listening--together efficiently predict scores on the same tests. These results are consistent with the extensive previous research demonstrating that cognitive abilities are important predictors of training success. Because the training of locomotive engineers is necessary for safe and efficient train handling, is legally mandated, is time consuming and expensive, it would benefit the railroads to identify those applicants who are most likely to successfully complete training. The cognitive ability tests developed in this project can identify such applicants. We recommend that railroads seriously consider using these tests to select applicants for engineer training. Finally, URC recommends the use of a physical exam to assess the applicant's ability to recognize colors, to reach with hands and arms, and to judge distance. Finally, URC recommends conducting additional validation research, including the testing of additional selection tests.

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INTRODUCTION

The locomotive engineer's job is highly demanding. The efficient management of train operations, including the safe handling of the train and maintaining train schedules, requires a number of skills and the knowledge of railroad rules and procedures. Locomotive engineers are responsible for knowing and complying with applicable safety and operating rules, conducting predeparture inspections, reading bulletins and general orders, monitoring gauges, properly using train braking systems, complying with speed restrictions, knowing the physical characteristics of the territory, and responding to unusual conditions.

The consequences of error in performance of the engineer's job, in terms of loss of life and destruction of property and equipment, are extraordinary. Improper or unsafe train handling can lead to severe consequences such as delays, equipment and cargo damage, derailments, collisions, and casualties. Therefore, railroads need to ensure that the individuals selected for (or promoted into) the engineer position have the skills and abilities necessary to learn how to perform engineer duties in a safe, efficient, and reliable manner.

The optimal approach for railroads to ensure that new engineers are capable of performing this demanding job is to select applicants for requisite abilities and skills and to provide legally required training (49 CFR, Ch. 11, Part 240) to those hired. The use of selection tests can increase the overall productivity of the workforce since the capabilities of the workers adequately meet the demands of the job. These productivity gains can be translated into dollar savings for the railroad. Boudreau (1991) reviewed published studies on the financial advantages to the organization of hiring more competent workers in a wide variety of jobs. Boudreau concluded that the overwhelming evidence is that selection programs pay off handsomely. Virtually every study has produced financial payoffs that clearly exceeded the costs of test development, validation, and implementation. Even the earliest studies that reported utility per person found that the payoffs exceeded costs. In studies dealing with more employees, multiple-year tenure, and more recent studies that take into account the effects of inflation, the utility estimates are always positive and have ranged into the millions of dollars.

The Federal Railroad Administration (FRA) has recognized that the railroad industry faces legal, economic, and public pressures to improve the quality and safety of train services. One way of doing this is by improving the selection of its operating personnel, especially engineers. The FRA supported this study to develop and validate a battery of selection tests that can be used for the identification of internal or external candidates for the engineer's job. The purpose of the project is to provide tests which the railroads can use to select engineer candidates who are capable of learning and later performing the job successfully. The dual objectives of ensuring that engineer candidates are able to complete training and to perform the job effectively are particularly important in an industry in which extensive training, both in the classroom and through on-the job experience, is required.

JOB ANALYSIS

The overall goal of this project is to develop valid and reliable instruments for the selection of engineer candidates. The foundation for building selection tests consists of defining the tasks performed in the job and identifying the skills and abilities which are required to perform these job tasks. A systematic method used to identify these job tasks and the knowledge, skills, abilities, and other personal characteristics (KSAs) necessary for effective job performance is job analysis. The results of the job analysis provide the basis for constructing selection tests and for collecting evidence of their validity or effectiveness.

A job analysis is typically conducted in four steps:

1. Preparation of a comprehensive list of tasks performed by workers in the job.

2. Identification of the most important and time-consuming tasks. We want to ensure that successful applicants have the capabilities to learn and to perform these tasks.

3. Identification of the KSAs which are likely to be important for effective job performance.

4. Ratings of these KSAs to determine those which are necessary for effective job performance. These are the KSAs which are necessary to perform the most important and time-consuming tasks performed on the job

STEPS IN THE JOB ANALYSIS

The job analysis conducted in this 'project was complex since several railroads joined the project after the initial job analysis was conducted. The following description of the project steps is presented to assist the reader in understanding the sequence of job analysis activities.

The engineer job analysis was first conducted in one railroad, Union Pacific (UP), using the four steps previously described:

1. Development of a task list at UP. The task list was written using information gathered from a literature review, observations of engineer performance (in November, 1986), and interviews with engineers, road foremen, and trainers.

2. Ratings of the tasks by UP engineers (in April, 1987) to identify the important and time-consuming tasks.

3. Preparation of a list of KSAs.

4. Ratings of the' KSAs by UP engineers (in June, 1987) to identify the important KSAs.

Four additional railroads (**Amtrak, Burlington** Northern, **Conrail,** and **Santa Fe**) joined the study in November, 1987. Because the results of **this** project were intended for industry-wide use, we decided to undertake job analyses at the additional railroads to expand our source of information about the engineer job. First, job experts at each of the additional railroads rated the tasks using the UP list (in December, 1988) to ensure the relevance and importance of these tasks. Second, the KSAs identified at UP were compared to the important KSAs in these additional railroads. The job analysis **findings** indicated that the engineer's job was essentially the same, in both the tasks performed and the KSAs, across the five Class 1 railroads participating in the study.

In February, 1990, a group of smaller railroads (Bessemer and Lake Erie; Elgin, Joliet, and Eastern; Union; and Duluth, Missabe, and Iron Range) volunteered to participate in the study. Because they were not Class 1 railroads, we were concerned that the tasks performed by locomotive engineers in these railroads might **differ** from those performed in the Class 1 railroads already participating in the project. In order to **identify** any differences, job experts in these railroads rated the UP task list for relevance to the engineer job in their railroad. The **results** further support the adequacy of the task list for the engineer's job.

Below is a more detailed description of the job analysis used in this study. In the description below, all the steps in the determination of the important engineer tasks, in both UP and in the additional railroads, will be presented together. Similarly, the steps involved in determining the important KSAs, required for Union Pacific engineers as well as for engineers in the other railroads, will be described together. **This** is being done for clarification of a complicated job analysis rather than to reflect the sequence of job analysis activities. The sequence was presented previously.

DETERMINATION OF THE IMPORTANT TASKS PERFORMED BY LOCOMOTIVE ENGINEERS

Review of Previous Research

Initially, the project staff reviewed studies on locomotive engineer job performance, including those which identified the tasks performed by locomotive engineers and the requirements for effective engineer performance. These studies include the ***Railroad Industry Job Analysis of Locomotive Engineer*** (Railroad Personnel Association 1981) prepared by C.H. **Lawshe,** the study by Hale and Jacobs **(1975),** and the study by **McDonnell** Douglas (1972) on the tasks performed during over-the-road freight operations. Project staff also reviewed a study University Research Corporation (URC) conducted concerning the task and KSAs of commuter rail engineers (Myers, **Harding,** Hunter, and Fleishman, 1985).

A preliminary list of locomotive engineer tasks was prepared using the task information available in these reports. Theinitial task list contained 31 tasks.

Site Visit

The project staff visited Union Pacific's **Training** Division in Salt Lake City in November, 1986 to discuss the initial task list with Union Pacific **(UP)** staff who conduct engineer training. The trainers eliminated, revised, and **clarified** some tasks, and added other to the provisional task list. In addition, the project staff, with a Union Pacific engineer trainer, rode in the engine cab on an over-the-road trip to observe engineer performance, equipment, and work conditions. Based on the meeting and observations, the preliminary task list was revised.

Review of Task List by UP Engineers

The revised list of job tasks was reviewed and further revised by seven locomotive engineers attending UP's Advanced Engineers Seminar and by nine UP general road foreman. The rating instructions and cover letter, developed for task ratings, were also reviewed and revised by the road foremen and by UP management. The final task list contains 39 tasks and is presented in Exhibit 1.

Task Ratings

Job tasks frequently vary in their criticality. The next step was undertaken to identify the tasks which are considered critical so that the KSAs of these tasks could be identified and analyzed. These tasks are the focus of the study since it is our concern that engineers have the capabilities to learn to perform these critical tasks.

Two Likert rating scales, time spent and task importance (presented in Exhibits 2 and 3) were used in this effort. Researchers (Sanchez & Fraser, 1992; Schneider & Schmitt, 1986; Thompson & Thompson, 1982) have discussed the usefulness of collecting both importance and time spent ratings in job analysis surveys. These two scales provide complementary information. Each scale provides a different perspective of task criticality. A task may be critical either because it is identified as important to the smooth, safe and timely operation of the train or because the engineer spends a great deal of time performing the task.

The rating forms were sent to 30 UP engineers. Twenty-six engineers (86.7%) returned the task ratings forms. Thirteen engineers were assigned to through-freight service, two to local service, two to yard service, and nine to other types of service. Exhibit 4 includes demographic information on the sample.

As a first step in the data analysis, descriptive statistics were run on the two task ratings: importance and time spent. The mean ratings on the two scales are presented in Exhibit 5. As can be seen from this exhibit, not every task was rated by every engineer. In order to obtain the most reliable ratings of each task, we analyzed the data using all the ratings obtained (which ranged from 23 to 26 raters). The grand mean of the time spent rating was 2.86 with the task rating means ranging form 1.22 through 4.42. These mean task ratings cover the gamut of rating levels. In contrast, the mean task importance ratings were generally higher, with a grand mean of 4.21 with task means ranging from 2.58 to 4.96.

The goal of the analysis of the task rating was to identify a set of critical tasks that would be the foundation for identifying the engineer KSAs. A task was considered critical if the mean rating for either the importance or time spent rating was 2.5 or above on the five-point rating scale. Because all of the tasks met the cut-off of 2.5 on the importance scale, we concluded that they all were critical and should be retained for the determination of engineer KSAs. The next analysis was the determination of

Exhibit 1

Locomotive Engineer
Task List

1. Obtain information required for trip including: train orders; special notices; general orders; work orders; special orders; load consist information; check train register.
2. Transmit information and/or instructions (in person or by electronic equipment) to other train crew members, dispatchers, mechanical force personnel, and other railroad employees.
3. Conduct job briefing by talking with crew about what needs to be done and how crew will operate to accomplish the job.
4. Inspect locomotive before run to verify quantity of fuel, sand, water, flagging equipment, and other supplies, as required by federal and company rules.
5. Sign daily inspection report, if no mechanical force personnel are available.
6. Start engines by operating switches, valves, and circuit breakers in proper sequence.
7. Perform initial terminal and other air brake tests as required by federal power brake law and company rules.
8. Receive and understand hand and radio signals.
9. After receiving proceed signal from appropriate person (e.g., yard master, conductor), operate controls such as throttle and air brakes to move train.
10. Read and comply with train orders, signals, and railroad rules and regulations while operating locomotive.
11. Use knowledge of territory and train makeup to plan in advance how to synchronize throttle and brakes in order to operate train safely and efficiently.
12. Call out (wayside) train signals as they come up and receive verification from other crew members in cab.
13. Relay wayside or cab signals to dispatcher using radio.
14. Repeat information heard form dispatcher over radio.
15. Check accuracy of speed indicator by using watch to measure time between mileposts.
16. Observe track and surrounding area to detect obstructions and to anticipate operating problems.
17. Identify malfunctions and reset protective devices.
18. Inspect locomotive and train during run to detect damage or defective equipment.

Exhibit 1 (continued)

Locomotive Engineer
Task List

19. Prepare 2A Engine Work Report.
20. Notify proper authorities and, if necessary, prepare reports to explain accidents, unscheduled stops or delays, and advise designated personnel as specified by federal or company rules.
21. Operate locomotive between various shop locations, service tracks, and switching areas.
22. Operate locomotive in yard to switch cars between tracks.
23. Pilot or supervise operation of trains where engineer is unfamiliar with territory.
24. Start train from stretched or bunched condition and on varying grades.
25. Stop train in stretched or bunched condition and on varying grades.
26. Control speed and slack of train by use of throttle, dynamic braking, and/or air brakes.
27. Change operating ends of locomotive consist.
28. Set out or pick up units on line (including connecting hoses or change hose mu cables).
29. Respond to unintentional application of automatic brakes.
30. Control throttle so as to avoid unnecessary stress on the engine, generator, traction motor and draw bars.
31. Operate helper locomotive under direction and in coordination with unit lead engineer.
32. Direct operation of helper locomotive by giving instructions to engineer.
33. Control operation of remote controlled engines.
34. Modify train handling techniques in response to operating problems, malfunctions and changing conditions.
35. Observe condition of passing train and report results.
36. Operate pace setter system.
37. Sound whistle and ring bell when approaching crossing and during impaired visibility conditions.
38. Operate telemetry equipment for cabooseless operations.
39. Respond to wayside signals of train problems (e.g., hot box signals).

Exhibit 2

Time Spent Scale

(1) How much time do you spend performing this task?

__________ **I generally spend a great deal of time performing this task.**

____

__________ **I generally spend a moderate amount of time performing this task.**

____

__________ **I generally spend a small or no amount of time performing this task.**

Exhibit 3

Importance Scale

(1) How important is the successful completion of this task for the smooth, safe, and timely operation of the train?

_____ of critical importance to the smooth, safe, and timely operation of the train

_____

_____ of moderate importance to the smooth, safe, and timely operation of the train

_____

_____ of little importance to the smooth, safe, and timely operation of the train.

Exhibit 4

Engineer Task Ratings
Description of Union Pacific Raters

Number of Raters	**26**
Age Mean (SD)	**42.4 (8.76)**
Gender	**23 men** **3 woman**
Ethnic Background	**23 White** **2 Hispanic** **1** *African* **American**
Years of Experience as an Engineer Mean (SD)	**19.5 (9.06)**
Years of Education Mean (SD)	**13.3 (1.77)**

Exhibit 5 (continued)

UP Task Ratings

Task	N	Time Spent Mean	Time Spent SD	Importance Mean	Importance SD
33	23	1.22	0.74	3.48	1.70
34	26	3.50	1.21	4.54	0.76
33	23	1.22	0.74	3.48	1.70
34	26	3.50	1.21	4.54	0.76
35	26	3.46	1.10	4.62	0.70
36	23	1.30	0.82	2.91	1.47
37	26	4.31	1.05	4.92	0.27
38	26	3.23	1.51	4.27	1.12
39	26	2.89	1.34	4.81	0.63

Exhibit 5

UP Task Ratings

Task	N	Time Spent Mean	Time Spent SD	Importance Mean	Importance SD
1	26	3.58	1.39	4.85	0.61
2	26	2.69	1.23	3.96	1.15
3	26	2.77	0.82	4.19	0.80
4	26	2.50	0.95	3.85	0.93
5	26	2.08	1.06	3.31	1.16
6	26	2.00	1.27	3.96	1.00
7	26	3.15	1.35	4.89	0.20
8	26	3.96	1.11	4.96	0.20
9	26	3.92	1.32	4.65	0.63
10	26	4.39	0.80	4.92	0.27
11	26	4.35	1.02	4.96	0.20
12	26	3.27	1.22	4.23	1.11
13	26	1.50	0.76	2.58	1.30
14	26	2.85	1.35	4.19	1.02
15	26	3.04	1.46	4.31	1.05
16	26	3.77	1.11	4.58	0.64
17	26	2.62	1.27	3.85	0.88
18	26	3.31	1.29	4.62	0.57
19	26	2.08	1.02	3.39	1.36
20	26	2.12	1.03	4.27	0.87
21	26	2.42	1.27	3.31	1.32
22	26	2.73	1.61	3.77	1.42
23	26	1.31	0.74	4.04	1.31
24	26	3.50	1.21	4.46	0.76
25	26	3.77	1.03	4.46	0.76
26	26	4.42	0.95	4.77	0.51
27	26	2.08	0.85	4.00	1.17
28	26	2.27	1.04	4.00	1.20
29	26	2.27	1.28	4.73	0.53
30	26	4.08	1.09	4.50	0.71
31	25	1.48	0.92	4.00	1.35
32	26	1.58	1.10	3.89	1.42

the inter-rater reliability of the importance and time spent ratings. Inter-rater reliability concerns the extent to which the raters agree in their judgments. The inter-rater reliability of each rating scale was estimated using intraclass correlation coefficients, which is the standard method for estimating the reliability of ratings (Guilford, 1954). The specific formula used assumes random effects from raters and for tasks (Shrout & Fleiss, 1979, p. 423). (The general case of intraclass coefficient is discussed in Appendix A).

The intraclass correlation coefficient for the time spent rating was .93 for the mean across 22 raters (for whom complete data were available). The coefficient for the importance ratings was .87 for the mean across 22 raters. These results indicate substantial agreement among raters in their assessment of the tasks.

Determination of the Important Engineer Tasks in the Other Railroads

As was previously described, eight additional railroads (Amtrak; Bessemer and Lake Erie; Burlington Northern; Conrail; Duluth, Missabe, and Iron Range; Elgin, Joliet, and Eastern; Santa Fe; and Union) agreed to participate in the study after the identification of important job tasks at UP. Because we intended the study to have applicability throughout the industry, we decided to broaden our study with information about engineer job tasks from the additional railroads.

The task review, in the eight additional railroads, was undertaken with the Union Pacific task list (see Exhibit 1). Each company was sent a set of task review forms and asked to have them filled out by a sample of personnel knowledgeable about the engineer job. The sample is presented in Exhibit 6. Each rater was asked if each task on the list (with the exception of two tasks eliminated because of differences in terminology across railroads) did or did not describe an important part of the engineer's job at their company. The results for each added railroad were analyzed to determine if the railroad engineer jobs were behaviorally similar enough to be considered the same as the engineer jobs at Union Pacific.

To evaluate the similarity in jobs across the railroads, we used an 80/80 rule. For a task to be considered part of the engineer's job, 80% of the raters must judge the task as part of the job in their railroad. In order for the engineer job to be considered similar to that performed at Union Pacific, 80% of the tasks on the Union Pacific task list had to be rated as part of the engineer's job in the other railroad. The ratings of all of the railroads were analyzed and each met this rule. Bessemer and Lake Erie; Union; and Elgin, Joliet and Eastern railroads all had an 81% overlap of tasks with the UP task list. The engineers from Duluth, Missabe, and Iron Range rated 86% of the UP tasks as being part of the engineer job. There was a 92% overlap at Amtrak, an 81% overlap at Burlington Northern, an 86% overlap at Conrail, and a 97% overlap at Santa Fe.

Despite variations in railroad rules and conditions, the original task list accurately described the engineer's job in the eight additional railroads, including both large and smaller railroads. Most tasks included in the original Union Pacific task list were rated as an important part of the engineer's job in each of the new railroads. Each railroad did, additionally, make some modifications to the task list. The revised task lists were used for the determination of the KSAs in these railroads.

Exhibit 6
Engineer Task Ratings
Description of Raters

	Amtrak	Burlington Northern	Conrail	Santa Fe	Bessemer Lake Erie	Duluth Missabe Iron Range	Elgin, Joliet, & Eastern	Union
Number of Raters	5	13	9	26	5	5	5	5
Age Mean (SD)	54.6(10.24)	43.3(9.05)	46.8(8.35)	43.8(7.6)	47.6(3.29)	45.4(11.33)	41.2(8.53)	51.6(10.31)
Gender	5 men	13 men	9 men	26 men	5 men	5 men	5 men	5 men
Ethnic Background	4 White 1 African American	12 White 1 American Indian	9 White	25 White 1 American Indian	5 White	5 White	5 White	5 White
Years of Experience as an Engineer Mean (SD)	18.2(6.91)	9.1(9.85)	16.7(11.61)	12.9(8.30)	13.8(9.18)	7.6(5.59)	12.2(10.23)	19.8(16.04)

DETERMINATION OF THE IMPORTANT ENGINEER KSA REQUIREMENTS

Having identified the important job tasks, the next step in the job analysis was the determination of the KSAs which engineers must have in order to perform these tasks effectively. These KSAs cover the skills, abilities, and other personal characteristics required for successful performance of the job.

The method used to identify the KSAs is based on the research of the project consultant, C.H. Lawshe. Dr. Lawshe developed an inventory of 51 KSAs organized into 13 categories. The categories are: understanding printed/written material; performing calculations; understanding oral communications; making oneself understood orally; making oneself understood in writing; understanding graphic information; exercising mechanical insight; making estimates; making choices/solving problems; making visual/auditory discriminations; using hands in work activities; making gross body movements; and climbing or balancing. The complete list of KSAs is in Appendix B.

Procedure to Identify KSAs

A group of 14 engineers attending UP's Advanced Engineering Training Course participated in this phase of study. (Exhibit 7 presents the demographic characteristics of the sample.) They were given the list of 39 locomotive engineer tasks that were prepared in the prior phase of the study and a rating form which listed the 51 KSAs. A URC job analyst administered the form and was available to explain the KSAs.

The rating form presented each of the 13 KSA categories on a separate page with the specific KSAs from the category listed below. The raters were asked to review each KSA and determine if it was or was not essential in order to safely and competently perform each job task. If the KSA requirement was considered essential, a check was written, and if it was not, a zero was written.

Reliability of UP KSA Ratings

The inter-rater reliability in the ratings made by these engineers was assessed using intraclass correlation coefficients (Shrout & Fleiss, 1979, p. 423). The average agreement, across the raters, as to whether a KSA was or was not necessary to perform a task ,was estimated at .79, using the 10 raters who made all of the ratings. (For ratings of the individual KSAs, all the ratings which were made were used in order to increase the reliability of the ratings).

In addition, the inter-rater reliability for each KSA was estimated separately using the same analytic method. The results are presented in Exhibit 8. Some of the reliabilities were quite low, indicating modest agreement in the judgments of some KSAs. Because of these results, a conservative procedure was used for identifying KSAs necessary for the job.

Identification of Necessary KSAs for UP Engineers

The KSA data were analyzed using the method suggested by Lawshe (1987, personal communication). The KSA data were a matrix of the number of raters who indicated that each KSA was or was not essential to perform each of the 39 tasks. According to Lawshe, a KSA is considered necessary for performing a task if significantly more than half of the raters rate it as essential to perform the task. Using this approach; we

Exhibit 7

Engineer KSA Ratings
Description of Union Pacific Raters

Number of Raters	**14**
Age Mean (SD)	**39.0 (6.33)**
Gender	**14 men**
Ethnic Background	**14 White**
Years of Experience as an Engineer Mean (SD)	**12.4 (3.50)**
Years of Education Mean (SD)	**13.1 (1.54)**

Exhibit 8

Inter-rater Reliability of the UP KSA Ratings

Category	KSA Specific Ability/Skill	Intra Class Correlation
Understanding printed/ written material	1	.62
	2	.65
	3	.68
	4	.53
	5	.72
	6	.32
Performing calculations	7	.65
	8	.61
	9	.53
	10	.57
	11	.40
Understanding oral communication	12	.83
	13	.70
	14	.24
	15	.51
Making oneself understood orally	16	.80
	17	.66
	18	.35
	19	.60
Making oneself understood in writing	20	.80
	21	.73
	22	.90
	23	.90
	24	.24
Understanding graphic information	25	.26
	26	.48
Exercising mechanical insight	27	.25
	28	.23
	29	.33
	30	.14

Exhibit *8* (continued)

Inter-rater Reliability of the UP KSA Ratings

Category	KSA Specific Ability/Skill	Intra Class Correlation
Making estimates	31	.41
	32	.48
	33	.52
Making choicesIsolving problems	34	.09
	35	.23
	36	.19
	37	.33
Making visuallauditory discrimination	38	.52
	39	.49
	40	.53
	41	.59
	42	.18
	43	.12
	44	.44
	45	.15
	46	.45
Using hands/fingers	47	.84
	48	.47
Gross body movements	49	.82
Climbing balancing	50	.82
	51	.80

<u>Note:</u> The numbers of these KSAs refer to the list of KSAs in Appendix B.

analyzed the ratings data to identify whether each KSA was necessary to perform each task. Exhibit 9 presents, for each KSA, the number of tasks for which the KSA was identified as necessary (i.e. rated by significantly more than half the raters as essential to perform the task).

Using this analysis, the following KSAs were rated as necessary to perform the greatest number of tasks: reading; coordinating work with co-workers through conversation/discussion where effectiveness depends upon understanding others; understanding oral instructions or work procedures; coordinating work with co-workers through conversation/discussion where effectiveness depends upon being understood; and memorizing.

We also reviewed the findings of three studies which analyzed the requirements of the locomotive engineer job. Hale and Jacobs (1975) determined, through expert judgment, the KSAs needed for safe operations of a train. The Railroad Personnel Association (1981) identified the KSA requirements of engineers, as rated by engineers and supervisors. Myers, Harding, Hunter, and Fleishman (1985) had a group of engineers and psychologists select the more important cognitive, perceptual, psychomotor, and physical ability KSAs.

All of the three studies identified reading as required for the engineer job. Two of the three identified speaking, memory and understanding oral instructions as necessary for effective job training and performance. The additional KSAs identified, in these studies, as necessary for the engineer job were: recognizing colors, making logical choices, judging speed and distance, understanding visual displays, problem sensitivity, time sharing, selective attention, exercising hand/eye coordination, and responsibility.

KSA Ratings in the Additional Railroads

The purpose of obtaining additional KSA ratings was to broaden the source of job analysis information. Job experts from four railroads (Amtrak, Burlington Northern, Conrail, and Santa Fe) participated in this phase of the project. They were sent KSA rating forms on which they indicated if each KSA was or was not essential to perform the tasks on the task list specially prepared for their company. The sample of raters for the four railroads is presented in Exhibit 10.

Because the KSA ratings were to be obtained using a mail-out procedure, we concluded that fewer KSAs should be included in the rating form than had been used previously at Union Pacific. We selected KSAs from those rated by Union Pacific engineers which were linked to several job tasks and those identified as important in other engineer job analyses. We added KSAs identified in a Conrail validation study as relevant to the job (Rahim Sheikholeslami, personal communication). The list of these KSAs is presented in Exhibit 11.

We then analyzed the KSA data from the four additional railroads, and reanalyzed the data from Union Pacific. The analysis involved determining the number of tasks identified as requiring each KSA. As stated previously, a KSA is considered necessary for performing a task if significantly more than half of the raters identify it as essential to perform the task. Exhibit 12 lists the number of tasks, in each railroad, for which a KSA was identified as essential.

Since each of the five railroads used task lists with different numbers of tasks, we could not directly compare the number of tasks linked to each KSA across railroads.

Exhibit 9

The Number of Tasks for Which Each KSA was Rated as Essential

KSA Category	KSA Number	Number of Tasks
Understanding printed/ written material	1	9
	2	6
	3	5
	4	4
	5	1
	6	9
Performing calculations	7	1
	8	0
	9	0
	10	0
	11	0
Understanding oral communication	12	15
	13	12
	14	0
	15	1
Making oneself understood orally	16	11
	17	6
	18	0
	19	0
Making oneself understood in writing	20	0
	21	0
	22	2
	23	2
	24	0
Understanding graphic information	25	0
	26	0
Exercising mechanical insight	27	0
	28	0
	29	0
	30	0

Notes: The numbers of these job requirements refer to the list of job requirements in Appendix B. The number of tasks is 39.

Exhibit 9 (continued)

The Number of Tasks for Which Each KSA was Rated as Essential

KSA **Category**	KSA **Number**	**Number of Tasks**
Making estimates	31	1
	32	0
	33	0
Making choiceslsolving problems	34	0
	35	0
	36	0
	37	0
Making visual/auditory discrimination	38	0
	39	0
	40	1
	41	2
	42	0
	43	0
	44	0
	45	0
	46	5
Using handslfingers	47	15
	48	0
Gross body movements	49	1
Climbing balancing	50	1
	51	0

Exhibit 10

Engineer KSA Ratings
Description of Raters

	Amtrak	Burlington Northern	Conrail	Santa Fe
Number of Raters	13	9	16	21
Age Mean (SD)	38.6 (7.07)	41.0 (3.54)	39.8 (0.71)	45.9 (7.07)
Gender	13 men	9 men	16 men	19 men 1 woman 1 missing
Ethnic Background	12 White 1 African American	9 White	16 White	20 White
Years of Experience as an Engineer Mean (SD)	11.0 (1.41)	9.0 (1.41)	12.5 (2.12)	16.5 (4.95)

Exhibit 11

List of KSAs Reviewed by Additional Railroads

1. Reading simple words, such as position signs on machine equipment (e.g., "On/Off", or "Start/Stop").
2. Reading simple sentences, such as posted signs or directions (e.g., "Keep boxes out of aisles").
3. Reading complex sentences, such as written material on work tickets or printed material on containers (e.g., "This material may explode if it gets wet").
4. Reading paragraphs which describe a thing or event or present multiple instruction in sequence, such as instructions in operating.
5. Memorizing and recalling specific information learned from printed materials.
6. Understanding oral instructions or work procedures information provided by supervisors or others.
7. Coordinating work with co-workers through conversation/discussion where effectiveness depends upon being understood.
8. Providing routine oral status or progress reports to supervisor or others, in person, by phone, or by radio.
9. Making choices/decisions in which the risks or consequence are slight, such as: sorting materials or parts.
10. Making choices/decisions affecting the security or well-being of others and/or which involve serious risk or consequences.
11. Recognizing colors, such as: light signals, containers, or electrical parts.
12. Maintaining attention to a task over long periods of time.
13. Judging distance from observer to objects and/or between objects.
14. Reaching-extending hand(s) and arm(s) in any direction.
15. Exercising hand-eye coordination.
16. Agreeable - good natured and cooperative.

Exhibit 11 (continued)

List of KSAs Reviewed by Additional Railroads

17. Conscientious - responsible, careful and dependable.
18. Calm - composed under stress.
19. General Activity - busy, active in projects.
20. Outgoing - likes to be with people.

Exhibit 12

Number of Tasks for Which each KSA was Rated as Essential in Each Railroad

	Amtrak	Burlington Northern	Conrail	Santa Fe	Union Pacific
Reading Words	10	8	15	12	9
Reading Sentences	8	8	7	7	6
Reading Complex	2	2	5	4	5
Reading Para	4	4	4	3	4
Memorizing	30	23	38	32	9
Understanding Oral	12	16	16	18	12
Coordinating	12	13	21	19	11
Providing Reports	11	2	19	11	6
Slight Choices	4	20	27	31	0
Serious Choices	2	8	8	21	0
Colors	9	5	7	11	1
Attention	17	11	23	20	5
Distance	17	11	23	19	2
Reaching	15	0	18	21	15
Hand-eye	18	1	20	23	--
Agreeable	1	0	13	4	--
Conscientious	34	9	38	37	--
Calm	11	7	33	20	--
Activity	0	0	0	0	--
Outgoing	0	0	0	0	--

Notes:
Amtrak rated 34 tasks
Burlington Northern rated 37 tasks
Conrail rated 39 tasks
Santa Fe rated 37 tasks
Union Pacific rated 39 tasks

Instead, the KSAs were ranked in terms of number of tasks linked to them. Two analyses were carried out to compare the rankings across the railroads. In one analysis, the 14 KSAs common to the ratings in all five railroads were compared. Kendall's coefficient of concordance (Walker & Lev, 1953, p.284) was used to compare the ratings of the KSAs. The coefficient of concordance is a measure of the agreement in the rankings of KSAs across raters (in this case, the railroads). The coefficient W is .53 (df = 13, $p < .001$). The coefficient, W, was also calculated for the 20 KSAs common to the four new companies. In this analysis, W equals .76 (df = 19, $p < .001$). (The program used for analyzing these data corrects for ties in the rankings.)

Both analyses indicated significant agreement in the ranking of KSAs. We can conclude that there is a consistency across the railroads in the KSAs identified as necessary for performing important engineer tasks.

Given this consistency, the most highly ranked KSAs were identified as appropriate for test development. These are:

- Reading
- Memorizing
- Understanding Oral Instructions
- Speaking
- Decision Making
- Recognizing Colors
- Attention
- Judging Distance
- Reaching with Hands/Arms
- Hand/eye Coordination
- Being Conscientious and Attention to Detail
- Being Calm

TEST DEVELOPMENT

TEST DEVELOPMENT GOALS

In preparing the test plan, we wanted the tests to be:

- Practical and feasible for the railroads. Considerations in making this decision include: ease of administration; objectivity in scoring; amenability to group or individual administration; and use of simple or minimal equipment.
- Look relevant to the job of locomotive engineer.
- Appropriate for both entry-level selection and for promotion.
- Relevant to the KSAs of the engineer job.

PRELIMINARY TEST PLAN

Using the test development goals for guidance, we prepared a plan concerning the measure of important KSAs identified in the job analysis. The preliminary test plan is presented in Exhibit 13.

We decided to develop several tests that would include engineer-relevant material. We thought that reading, memory, logic and attention tests could be feasibly developed using engineer-relevant content. Published tests measuring other KSAs were already available. These tests included measures of understanding oral instructions, conscientiousness, and calmness.

When reviewing the literature on measures of attention, we identified a dichotic listening test which predicts pilot training success (Gopher, 1982; Gopher & Kahneman, 1971) and reduced accident rates in bus drivers (Kahneman, Ben-Ishai, & Lotan, 1973). The test requires participants to maintain attention to information presented to a designated ear and to ignore information simultaneously presented to the other ear. Dr. Glen R. Griffin, of the Naval Aerospace Medical Research Laboratory provided URC with a tape recording of the dichotic listening test he was using in research on Navy pilots.

The literature on judging distance was extensive but we were unable to find any measures of distance perception that would be feasible for selection testing. Instead, we recommend that distance perception be evaluated during a physical exam. We also recommend that recognizing colors and reaching with arms/hands be assessed during a physical exam.

TEST REVIEW AND COMPLETION

In November, 1988, representatives from the railroads participating in the study at that time (Amtrak, Burlington Northern, Conrail, Santa Fe, and Union Pacific) and Garold Thomas, the FRA project monitor, met with URC project staff to review the draft test plan and examples of test items.

Exhibit 13

Preliminary **Test** Plan

KSA	Recommended Test
Reading	Specially Developed Test
Memorizing	Specially Developed Test
Understanding Oral Instructions.	Published Test
Speaking	Interview
Making Choices and Decisions	Specially Developed Test
Recognizing Colors	Physical Exam
Attention	Specially Developed Test and Dichotic Listening Test
Judging Distance	Physical Exam
Hand-Eye Coordination	**URC** Computerized Test
Reaching with **Hands/Arms**	Physical Exam
Conscientious	Published Test
Calm	Published Test

In general the company representatives liked the test battery. They made specific suggestions regarding the content, format and instructions of several of the tests. The group did not like the published test measuring understanding oral instructions. They thought it was too clerical in nature and suggested that it be revised with engineer content. The representative from **Burlington** Northern volunteered to assist us in the development of an alternative test. The group **also** decided to refrain from using measures of the personality KSAs because these tests were considered intrusive. The meeting participants also decided not to use **a** computerized test of hand-eye coordination because of limited availability of personal computers in the railroads. The group also recommended assessing the reading level of the reading test to ensure it was consistent with the reading level required for the job.

The tests were revised and completed consistent with the recommendations given by the railroad representatives. The revised test plan is presented in Exhibit 14.

TESTBATTERYPRETESTS

During February, 1989, we conducted two pretests of the test battery with railroad engineers and road foremen. At **Conrail,** two road foremen, two engineers, and two engineer instructors participated in the pretest. At Amtrak, six road foremen and one transportation manager participated in the pretest. Demographic information about the samples presented in Exhibit 15.

These pretests were conducted to identify confusing test items and instructions **as** well as to estimate the time required for each test in the battery. The procedure for the pretests involved explaining the project to the participants, administering a test, discussing the test, and going on to the next test. As a result of these pretests, the tests were edited and the instructions were simplified.

During March and April, 1989, a third pretest was undertaken. The purpose of the pretest was to **identify** problem items for elimination, **editing,** or replacement. Because a large sample is required for item analysis, we decided to collect data a at college where it was more feasible to obtain a large sample than at a railroad.

Participants were volunteers from three colleges: the University of Virginia, the University of Maryland, and Piedmont Virginia Community College. The number of participants who took each test at each school is in Exhibit 16.. The professors requested that no background data be collected so that we have no demographic information about the pretest sample.

During this pretest, we determined the length of time it took for the participants to complete each test. We wanted to determine time limits which allowed all the candidates to complete each of the tests, except for the perception test, which was prepared as a speeded test. The participants also **identified** unclear items.

Item analyses were also conducted. Items were considered for elimination or revision if: the item was not correlated with total test score; if one wrong answer was frequently selected; and, if the item was exceedingly hard or easy so that there was little variability. As a result of the pretest, test items were edited and eliminated. Additional items were also added.

After revision of the reading test, we evaluated the reading level to ensure that

Exhibit 14

Revised Test Plan

KSA	Recommended Test
Reading	Specially Developed Test
Memorizing	Specially Developed Test
Understanding Oral Instructions	Specially Developed Test
Speaking	Interview
Making Choices and Decisions	Specially Developed Test
Recognizing Colors	Physical Examination
Attention	Dichotic Listening Specially Developed Test
Reaching with Hands/Arms	Physical Exam
Judging Distance	Physical Exam

Exhibit 15

Pretest of Test Battery
Description of Participants

	Amtrak	Conrail
Number of Raters	7	6
Age Mean (SD)	40.4 (5.32)	39.7 (7.06)
Gender	7 men	6 men
Ethnic Background	7 White	6 White
Years of Experience as an Engineer Mean (SD)	15.4(3.69)	8.5 (6.72)

the verbal complexity of this test was no more difficult than the materials that must be read and understood on the job. In order to assess the relative difficulty of the reading test, we requested that the railroads provide us with documents that what engineers read on the job. The railroads provided us with rules and regulations.

We evaluated the complexity of the test passages and company materials using the Flesch Reading Ease Index, which is calculated using the computer program Grammatik II. The Flesch formula is based on sentence length and the number of syllables per hundred words in samples from prose passages (Flesch, 1948). The formula was used to calculate the reading level of the reading passages in the test and in the selected passages (of approximately two pages in length) from materials sent by each railroad.

The reading level of the test passages was equal or lower than that of the reading material used on the job. The reading test complexity level was 11th grade level. The materials from Amtrak and Santa Fe required at the 11th grade reading level; those from Conrail required a 12th grade reading level; and the passages from Burlington Northern and Union Pacific required a college sophomore reading level.

FIRST VALIDATION STUDY

VALIDATION OVERVIEW

Validity is the most important consideration in test evaluation. The term refers to the appropriateness, meaningfulness, and usefulness of the inferences made from test scores. Test validation is the process of accumulating evidence to support such inferences. Personnel selection tests are used to predict future job relevant performance. In personnel selection, then, the inference made from a test score is an inferences about future job or training performance. The evidence used to support test validity in selection research is the demonstration of a useful relationship between the test scores and one or more measures of job relevant behavior.

In this project, the engineer test battery was validated in two studies. Each study involved four steps:

1. Development of a measure of engineer performance. This is called the criterion measure. In the first study, the criterion measure was a supervisory rating of job performance. In the second study, measures of training performance were used.
2. Identification of a sample of engineers.
3. Administration of the test battery to the engineers and collection of criterion data evaluating their performance.
4. Analysis of the relationship between test performance and engineer performance. In this project, validity is indicated by the empirical relationship between performance on the tests and scores on the criterion measure.

We will discuss each study separately. Following is a description of the method and results of the first validation study.

CRITERION DEVELOPMENT

The goal of this study was to develop and validate a battery of tests for selecting candidates most able to competently perform the locomotive engineer job. There were complications in the identification of an appropriate measure of engineer job performance. Several options were considered. One option was a rating of job performance filled out by the supervisor based on his/her prior observations of job performance. The major factor complicating the development of this measure was the lack of frequent observations of engineer performance. Road foremen may ride with engineers only once in six months. The other personnel (switchman, brakemen) who consistently ride with engineers are not trained or experienced to evaluate engineer job performance.

We also considered the use of discipline, accident, and incident records. Railroads were reticent to allow us access to personnel records. An additional option considered was the use of the records made by event recorders mounted on locomotives. Although the records from these recorders can be used to evaluate speed, braking, and stalling, the track and route must be considered in evaluating each tape. Since there were no consistent rules for evaluating these records and linkage of the record with a specific engineer might be problematic, we concluded that this measure should not be used.

Instead, we decided to develop an observational rating form that would be used by road foremen. As a first step in preparing the observational rating form, we reviewed the reports which described specific engineer behaviors. Among the documents reviewed were ***Railroad Engineman Task and Skill Study*** (McDonnell Douglas Corp. 1972) and ***Railroad Engineer Task and Skill Analysis*** (Louisville & Nashville Railroad, 1981). In addition, the engineer rating forms for Norfolk Southern, Conrail, and Union Pacific were reviewed. We also spoke to Union Pacific road foreman concerning the key components of engineer performance, the behaviors they are able to observe and the common errors that engineers make.

Using the information from the literature review and interviews, we compiled a list of pre-start and enroute tasks performed by engineers. Special emphasis was placed on train handling tasks as it was felt that differences between engineers would most likely occur in this aspect of the job. These tasks were the basis for a road foremen observation guide. The draft observation guide was reviewed by Amtrak, Burlington Northern, Conrail, Santa Fe and Union Pacific road foremen and trainers. Based on all of their comments, revisions and additions were made to the rating form.

The final version of the observation form includes nine dimensions of job performance: prestart, rules compliance, operating equipment, starting, accelerating, controlling speed, negotiating a cresting grade, stopping, and switching. For each dimension, there were specific behaviors which were rated according to whether or not the engineer followed acceptable procedures. These ratings were called specific behavior ratings.

In addition, for each dimension, there was a five-point rating scale (ranging from unsatisfactory to outstanding) for rating overall performance on that dimension. A sixth rating option was available if it was not possible to observe behaviors relevant to the dimension. These ratings were called dimension ratings. In addition to the evaluations of specific behaviors and to dimension ratings, each supervisor was asked to rate the difficulty of the trip, considering factors such as the territory, time of day, and weather. This rating was made on a five point scale from easy to difficult. The rating form is in Appendix C.

VALIDATION OF THE TEST BATTERY

The objective of the validation was to secure evidence that the test battery was useful for the selection of locomotive trainees. A criterion-related validation study was used to evaluate the validity of the test battery. Evidence for criterion-related validity consists of a demonstration of a statistical relationship between the scores on the test battery and ratings on the criterion measure. In this project, both test and criterion data were obtained for incumbent engineers.

Selection of the Sample of Engineers

In designing the validation study, consideration was given to selecting the validation sample, collecting test data, and obtaining the criterion data. The plan for the validation sampling was based on technical and practical considerations. A key consideration in designing the sampling plan was the cost for the railroads. Because of engineer contracts and schedules, it was costly to have engineers participate in the validation. The cost of participation limited the number of engineers that any railroad could provide for the study. The railroads also determined that only engineers who volunteered should participate. Because of the costs for test administration, URC concluded that the tests had to be administered to groups of engineers rather than to individuals.

These considerations led to a plan for sample selection in which railroads were asked to identify the number of engineers they could provide in a Limited number of'testing locations. After selecting feasible locations, the railroads asked for volunteers, at the locations, who would be willing to participate in the validation. Although URC requested that the railroads try to include a representative sample of engineers, in terms of race, sex, and competence, use of only volunteers did not ensure a diverse sample of engineers.

Collection of Test Data

URC project staff undertook all test administration and processing. Instructions for each test administrator were prepared so that instructions, timing, and explanations were consistent across the sessions.

Company coordinators were asked to identify specific times and locations for test administration. They were also asked to inform the engineers about the study. The participants, however, did not receive any instructions or information regarding the specific tests prior to the testing session.

At the onset of each testing session, the URC test administrator provided a brief overview of the project, summarizing the earlier phases of the study, and describing the purpose of the test validation. The participants were assured that the test and job performance data would remain confidential, and be used only for the purposes of the validation study.

The participants then filled out background information forms. The tests were administered in the following order: Memory, Reading, Perception (measuring attention to detail), Understanding Oral Instructions, Logical Reasoning, and Dichotic Listening. The test administrator read the instructions for each test and the participants were given only those test materials. All of the tests were timed. However, except for the Perception and Memory tests, all the participants were given all the time they needed to complete each test. The test administrator was asked to record any instances when additional time was required, beyond the time limits.

Collection of Criterion Data

The railroad representative who arranged for the validation, at each site, was given a set of engineer observation forms after the testing, and asked to distribute them to the road foreman who supervised each of the engineer participants. The observation form contained instructions for its completion. The railroad representatives were asked to contact URC project staff if they, or the road foremen, had any questions regarding the observation form or the validation study.

The railroad representatives were asked to have the road foremen use the observation form during a normal ride with the engineers. The instructions on the observation form request that the road foreman read the form before the trip and fill out the form immediately upon completion of the ride. The forms were to be returned to the railroad representative who was asked to send the entire set to URC.

Addition of New Railroads

The five participating railroads (Amtrak, Burlington Northern, Conrail, Santa Fe, and Union Pacific) were having difficulty meeting the sample size requirements of the validation study, due to the costs of providing engineers for testing and the difficulties in coordinating the collection of the criterion data. The data collection was taking place more slowly and with fewer engineers than had been anticipated. The delay in the receipt of the observation rating forms was particularly problematic.

We decided that the inclusion of additional railroads in the validation study would reduce the burden on the companies participating in the study and increase the size of the sample of engineers. We contacted the Railroad Personnel Association to help us identify additional railroads willing to participate in the study. As a result, four additional railroads, Canadian Pacific, Chicago Northwestern, CSX, and Norfolk Southern, agreed to participate in the validation phase of the study. Later in the project, a group of smaller railroads (Bessemer and Lake Erie; Elgin, Joliet, and Eastern; Union; and Duluth, Missabe, and Iron Range) volunteered to participate. As a result of the inclusion of the eight new railroads, we were able to complete the validation study. The railroads participating in the validation data collection, the dates of testing, and the number of engineers involved are listed in Exhibit 17.

Description of the Sample

One hundred and eighty engineers from eleven different railroads participated in the study. The largest number of engineers from any single railroad was 28, and the smallest number was eight. Complete data sets, including both test and criterion data, were available for 143 engineers. The latter sample was the sample used for the validation. Demographic information about the sample is presented in Exhibit 18.

Data Analysis

Analysis of the Selection Tests: Internal Consistency

Initially, the items in each of the tests were correlated with the total score on the test to identify items which were not internally consistent. Three items were thus eliminated and the tests were rescored. The mean scores for the tests are presented in Exhibit 19.

The internal consistency reliability of the tests was then assessed using coefficient alpha. Coefficient alpha is a numerical index of the extent to which the items on a

Exhibit 17

Companies Participating in FRA Locomotive Engineer Validation Study

Railroad	Testing Site	Date	Engineers Tested
Amtrak	Washington, DC	June 27, 1989	7
	New York, NY	June 28,1989	6
	Chicago, IL	March 30, 1990	3
Burlington Northern	Overland Park, KS	August 2,1989	10
Canadian Pacific	Agincourt, ON	September 6-7, 1989	13
	Toronto, ON	March 26, 1990	14
Chicago Northwestern	Naperville, IL	July 25, 1989	8
Conrail	Greentree, PA	May 22, 1989	6
	Indianapolis, IN	May 26, 1989	3
	Harrisburg, PA	June 2, 1989	4
	Dearborn, MI	June 6,1989	3
	Philadelphia, PA	June 8, 1989	6
	Selkirk, PA	June 13, 1989	6
CSX	Evansville, IN	August 15-16, 1989	17
Duluth, Missabe & Iron Range	Duluth, MN	July 16-17, 1990	10
Elgin, Joliet & Eastern	Joliet, IL	July 18-19, 1990	12
Norfolk Southern	Atlanta, GA	August 2, 1989	10
	Chattanooga, TN	April 2-3, 1990	16
Union	Pittsburgh, PA	July 9-10, 1990	10
Union Pacific	Salt Lake City, UT	March 23,1990	16

Exhibit 18

Validation Study 1
Description of Participants

Demographics	
Number of Participants	143
Age Mean (SD)	40.5 (8.90)
Gender	141 men 1 woman 1 unknown
Ethnic Background	13 African American 126 White 3 Hispanic
Years of Experience as an Engineer Mean (SD)	12.0 (9.28)

Exhibit 19

Test Mean Scores (Study 1)

Test	Mean Score	SD
Memory	21.66	7.19
Reading	31.21	5.38
Understanding Oral	27.19	5.08
Perception	13.92	3.66
Logical Reasoning	19.51	6.21
Dichotic Listening	168.88	21.74

test measure a single trait. The internal consistency results presented in Exhibit 20 indicate that the five tests show adequate levels of reliability. It should be noted that the reliability of the Perception test could not be estimated using coefficient alpha, because the perception test is a speeded test. A speeded test is one in which no examinee has time to complete all of the items. Internal consistency indices of reliability are spuriously high for speeded tests (Anastasi, 1988).

Analvsis of the Selection Tests: Inter-test Correlations

The correlations among the six tests in the test battery are displayed in Exhibit 21. Not surprisingly, all of the cognitive ability tests (Memory, Reading, Understanding Oral Instructions, and Logical Reasoning) were significantly correlated. The Perception and Dichotic Listening tests were less highly correlated with this set of tests and were not correlated with each other.

In order to refine our understanding of the relationships among the tests, a nonorthogonal principal components analysis with varimax rotation was used. (Appendix A presents a brief explanation of principal components analysis.) This procedure is intended to identify the underlying factors that account for the correlations among the tests. The results indicate two factors: (1) a cognitive factor, underlying performance on the Memory, Reading, Understanding Oral Instructions, and Logical Reasoning tests; and (2) a perception factor. The Dichotic Listening test loaded on the cognitive ability factor, but to a lesser extent than did the Memory, Reading, Understanding Oral Instructions, and Logical Reasoning tests. The Memory test loaded on the perception as well as the cognitive factor. This rather unexpected finding may be explained by considering the content of the Memory test. The test requires the applicant to remember codes (which are figures) and the operating principle associated with the code. Exhibit 22 presents the factor loadings. Together, the two factors account for 62.2 percent of the variance in test scores.

Analvsis of the Criterion Measure

For each engineer, two sets of ratings were used to evaluate engineer performance. One set was the ratings of specific behaviors. For each behavior, a "yes" rating (indicating adequate performance) was scored +1, a "no" rating (indicating unacceptable performance) scored -1, and a rating of "not observed or "not applicable" scored 0. The ratings for all of the behaviors within each dimension were then summed. In order to interpret these scores, one needs to consider the number of behavior ratings for each dimension. The number of behaviors for each dimension are: Prestart (6); Rules Compliance (15); Operation of Equipment (10); Starting the Train (10); Accelerating (4); Controlling Speed (17); Negotiating a Cresting Grade (6); Stopping a Train (12); and Switching (6). The mean specific behavior ratings (not corrected for the number of items), along with the mean dimension ratings, are in Exhibit 23.

These summed ratings do not provide information about the relative use of the three rating options. In order to better understand the ratings, we analyzed the percentage of engineers receiving each rating (see Exhibit 24). Of the 86 specific behavior ratings, the mean number of "yes" ratings was 49.9, the mean number of "no" ratings was 1.4, and the mean number of "not observed/not applicable" ratings was 33.7. It appears that on 'the specific behaviors, engineers were rated as either performing acceptably, or a rating of not observedlnot applicable was given. Very few responses of inadequate performance were given.

Exhibit 20

Internal Consistency Estimates of Reliability of the Predictor Tests

Test	Coefficient Alpha
Dichotic Listening	.98
Logical Reasoning	.88
Memory	.85
Understanding Oral	.77
Reading Comprehension	.82

Exhibit 21

Inter-test Correlations

	Memory	Reading	Perception	Understanding Oral	Logical Reasoning	Dichotic Listening
Memory	1.00					
Reading	.44**	1.00				
Perception	.23*	.05	1.00			
Understanding Oral	.31**	.50**	-.01	1.00		
Logical Reasoning	.49**	.70**	.14	.57**	1.00	
Dichotic Reasoning	.20*	.11	.11	.09	.18	1.00

Notes:
* $p < .01$
** $p < .001$

Exhibit 22

Principal Components Analysis of the Predictor Tests

	Rotated Factor Matrix	
	Factor 1	Factor 2
Memory	54	.60
Reading	.88	.02
Perception	-.02	.94
Understanding Oral	.72	.06
Logical Reasoning	.86	.21
Dichotic Listening	.33	.06

Exhibit 23

Descriptive Statistics on the Criterion Measure

		Specific Behavior Rating		Dimension Rating	
	N of Items	Mean	SD	Mean	SD
Prestart	6	5.31	1.08	3.15	0.44
Rules Compliance	15	9.68	1.92	3.18	0.44
Operation of Equipment	10	2.48	2.15	3.15	0.43
Starting	10	5.73	2.15	3.15	0.43
Acceleration	4	2.71	1.19	3.15	0.52
Controlling Speed	17	10.43	3.83	3.18	0.51
Negotiating Crest Grade	6	4.13	2.02	3.23	0.49
Stopping	12	8.46	3.37	3.18	0.53
Switching	6	3.84	2.79	3.28	0.47
Sum of All Dimensions	86	49.97	11.54	25.60	2.76

Notes:
N = number of subjects

Specific behaviors refer to the specific behaviors which are rated on the Engineers Rating Form in Appendix B.

The dimension rating is the rating for the entire dimension or category of behaviors, e.g., Prestart.

Exhibit 24

Percentage of Engineers Receiving Each Rating

Dimension	Performed Acceptably	Performed Unacceptably	Not Performed	Missing
Prestart	89.16	1.75	8.68	0.40
Rules Compliance	68.33	1.76	28.28	1.63
Operation of Equipment	34.68	0.30	64.72	0.30
Starting the Train	59.11	1.76	38.99	0.18
Acceleration	70.63	2.18	26.60	0.60
Controlling Speed	65.22	2.82	31.85	0.11
Negotiating Crest Grade	70.73	0.98	28.28	0.00
Stopping Train	72.23	1.90	24.42	1.45
Switching	58.57	0.40	38.63	2.40
Mean	65.4	1.5	32.3	0.79
(SD)	14.60	0.83	15.09	0.84

The dimension ratings (scored 0 for "not observed", and between 1 for "unsatisfactory" to 5 for "outstanding") indicated positive, but not extreme, ratings. The mean ratings for each dimension were in the satisfactory range rather than the superior or outstanding range (see Exhibit 23). Since a number of engineers were not rated on the Switching dimension, presumably because there were few instances of this behavior observed during the runs, we decided to drop this dimension--both the specific behaviors and the dimension rating--from further analysis.

The first step in determining how to score the criterion was to decide whether we should combine the ratings of specific behaviors across dimensions (to derive a sum of behavior rating) and combine the dimension ratings (to derive a sum of dimension score). Internal consistency analyses of the dimension ratings and the behavior ratings were undertaken. Coefficient alpha was used as an indicator of the degree to which the individual ratings were internally consistent (i.e., correlated with each other). The coefficient alpha for the behavior ratings was .89 and the coefficient alpha for the dimension ratings was .71. Based on these results, we decided to use the sum of the behavior ratings and the sum of the dimension ratings as the criteria for this study.

We then wanted to see whether these two sets of ratings were correlated. We correlated the behavior ratings, for each dimension, with the dimension ratings. The correlations are presented in Exhibit 25. These correlations are modest to moderate. The correlation between the sum of the behavior ratings and the sum of the dimension ratings is similarly modest. These results indicate that the sum of the dimension ratings and the sum of the behavior ratings should not be combined.

A small study was undertaken to evaluate the reliability of the criterion ratings. A test-retest approach was used to estimate the reliability of the ratings. This approach was used since the railroads indicated that it was neither feasible nor appropriate to have two supervisors rate an engineer's performance. Twenty-five engineers at UP were evaluated twice using the observational rating form. The intervals between the data collection ranged from one week to over one month. The test-retest reliability of the sum of the behavior ratings was .42 ($N=17$, $p > .05$) and the sum of the dimension ratings was .62 ($N=25$, $p > .05$). Both results indicate that there is only modest consistency in the ratings over time.

Analvsis of the Validation Results

The first analysis of the validation data was the examination of the correlations between the tests in the battery and criterion ratings (the sum of the dimension ratings and the sum of the behavior ratings). Exhibit 26 displays these correlations. None of the correlations were statistically significant. These correlations indicate that the tests in the selection battery were not effective predictors of the performance ratings. Subsequent multiple regression analyses support this conclusion. (Brief explanations of multiple regression and statistical significance are presented in Appendix A.) The multiple correlation between the six tests and the sum of the behavior ratings was .22 ($df=6$, 115, $F=.98$, $p > .05$). The multiple correlation of the six tests and the sum of dimension ratings was also not significant ($R=.21$, $df=6$, 102, $F=.75$, $p > .05$). In order to determine if there might be non-linear relationships, we prepared scatterplots of the relationships between the tests and the criterion measures (presented in Appendix D).

Exhibit 25

Correlations of Behavior Ratings and Dimension Ratings

	Correlation	N
Prestart	.21*	137
Rules Compliance	.28**	138
Operation of Equipment	.14	132
Starting	.39**	141
Acceleration	.39**	139
Controlling Speed	.28**	139
Negotiating Cresting Grade	.13	123
Stopping	-.06	131
Switching	.14	99

Correlation Between the Sum of Behavior Ratings and the Sum of Dimension Ratings (Excluding Switching)

r = .26**

Notes.
$^*p < .05$
$^{**}p < .01$
N = number of subject

Exhibit 26

Correlations Between Selection Tests and Criterion Ratings

	Sum of Behavior Ratings	Sum of Dimension Ratings
Memory	-.04	-.10
Reading	-.04	.11
Perception	-.03	-.04
Understanding Oral	.00	.11
Logical Reasoning	-.16	.05
Dichotic Listening	-.02	-.02

These scatterplots also indicate no discernible relationship between the tests and the job performance ratings.

In an attempt to shed insight on why the tests were not predicting the criterion scores, we examined the test and criterion correlations, undertaken separately for each of the participating railroads. Exhibits 27 and 28 display these correlations for the individual railroads. The correlations do not indicate that the tests are valid for individual railroads or even consistent across railroads. For example, the correlations between the memory test and the sum of the behavior ratings (see Exhibit 27) range from -.80 to .60.

Potential explanations of these low correlations could focus on the tests, the criterion scores, or both. Examination of the tests reveals no substantial evidence that the tests failed to capture the KSAs they were developed to measure. The tests also measured important KSAs. As depicted in earlier sections of this report, the tests displayed adequate internal consistencies and reasonable means and standard deviations. Both the pattern of test intercorrelations and the factor analysis results are interpretable. Furthermore, much previous research attests to the efficacy of cognitive ability tests for predicting performance across a wide variety of jobs and organizations (Hunter & Hunter, 1984). Hence, it seems reasonable that we could expect these tests to predict job performance for locomotive engineers.

Consideration of the criterion scores suggests several potential explanations for the low correlations. The reliability study results suggest the presence of measurement error in the ratings. Variance due to differences among raters, railroads, and the nature of the run (e.g., terrain, time of day, difficulty, duration of trip, weather) could introduce error into the criterion scores.

However, the major reason for the low correlations lies in the limited variability in the ratings. For the sum of the behaviors, there were very few instances of "no" ratings, indicative of unacceptable performance. For the dimension ratings, raters displayed a strong tendency to label the engineers performance as satisfactory, rather than extremely good or extremely poor. The large number of moderate ratings reduced the likelihood of significant correlations between the tests and criterion scores.

Why did we obtain these results? The road foremen observing the engineers made observations on only one run in order to rate an engineer. They were probably reluctant to make extreme ratings with only the Limited opportunity for observation. Second, performance on known territory, under most conditions, is overlearned. There are reduced opportunities for error when the engineer has performed this task over and over again. The engineers in the study were also likely to try to perform acceptably, or at least to refrain from unacceptable practices, when they were being observed by their supervisors. Any of these factors, or some combination of them, could have caused the lack of validity in engineer ratings.

Exhibit 27

Correlations Between Selection Tests and Sum of Behavior Ratings By Railroad

Railroad	N	Memory	Reading	Perception	Understanding Oral	Logical Reasoning	Dichotic Listening
1	10	.60	.62	-.08	.29	.71	-.22
2	8	-.45	-.16	-.32	.28	-.40	.50
3	13	-.03	-.20	.16	-.37	.52	.16
4	22	-.39	.12	-.24	.25	-.05	-.03
5	1						
6	9	.02	-.73	-.28	-.65	-.56	-.29
7	9	.32	-.05	.07	-.09	.04	.45
8	3	-.80	.87	.95	.98	-.91	-.99
9	10	.35	-.61	.44	-.18	-.21	-.05
10	7	-.39	-.21	-.04	.39	.10	-.01
11	2						

Notes:
N = number of participants

It was not possible to analyze the data from the railroads with only one and two subjects.

Exhibit 28

Correlations Between Selection Tests and Sum of Dimension Ratings by Railroad

Railroad	N	Memory	Reading	Perception	Understand-ing Oral	Logical Reasoning	Dichotic Listening
1	10	-.26	.23	.02	-.34	.30	.12
2	8	-.70	-.47	-.03	.02	-.44	.35
3	13	-.14	.25	-.26	-.21	-.10	.27
4	22	-.37	-.19	-.10	.23	-.25	-.34
5	1						
6	9	.48	-.01	.13	.05	-.13	.12
7	9	.52	.25	.04	.75	.69	.59
8	3	-.56	.65	1.00	.87	-.99	-.89
9	10	.09	-.23	-.17	-.37	-.40	-.40
10	7	-.48	-.55	.29	-.12	-.04	.31
11	2						

Notes:
N = number of participants

It was not possible to analyze the data from the railroads with only one and two subjects.

SECOND VALIDATION STUDY

The purpose of the second validation study was to determine if the test battery predicts training performance. Training performance is a critical precursor of engineer effectiveness. The importance of both training and the evaluation of training is indicated in the Federal regulations concerning engineer certification. According to CFR 49, Part 240, *Qualifications and Certification of Locomotive Engineers* (1994), each railroad shall have a written program for certifying locomotive engineers. Part of the certification must include classroom training in safety, operating rules, mechanical equipment, regulations, and skill training in train handling procedures. Each railroad shall also have procedures for testing knowledge and examining skill performance.

We obtained the cooperation of the Burlington Northern Railroad (BN) to assess the validity of the test battery in predicting training performance. URC project staff administered the battery of tests to engineer trainees at BN during their classroom training. Their training starts with 30 days of on-the-job training in which the trainee rides with an engineer trainer, observes the trainer operate the train, and receives instruction in train handling procedures, safety and mechanics, and sometimes, operates the train. The second phase of training is three weeks of classroom instruction. During this time, the trainees were given the test battery, using the same procedures as used in the prior validation study.

At the end of the three weeks of classroom instruction, the trainees practice on a simulator built by IIT Research Institute (IITRI). Trainees are assigned blocks of time on the simulator. Then the trainees return to their home territory and spend approximately 10 weeks operating trains under the supervision of a qualified engineer. In the last two weeks of their training, the trainees take the final written examinations and the simulator evaluations. These written examinations and the simulator evaluation served as the criterion measures for the second validation study.

CRITERION PROCEDURES AND SCORING

The criterion measure scores were provided by the BN Technical Training Center. The criterion measures were the combined score on the final simulator runs and the scores on the two final knowledge exams.

Final Examinations

In the last two weeks of their engineer apprenticeship, the trainees took the final written examinations which evaluate the knowledge acquired through training. The examinations consisted of two tests, each with 300 multiple choice questions. The exams are administered on two consecutive days. The first day the trainees take the General Code of Operating Rules test and on the second day they take the Air Brake and Train Handling rules test.

Performance Evaluations

The simulator examinations included three separate runs, each administered on one of three consecutive days. The simulator examinations were designed to measure the trainees' skills in train handling. The first run (Orin) contributes 40% toward the total simulation evaluation score. The purpose of this run is to test responses to centralized traffic control (CTC) block signal indications while handling a 110-car loaded coal train. The trainees are randomly assigned to one of three variations of this run which takes one hour and 15 minutes. The second run (Billings) contributes 40% toward the total simulator examination score. The purpose of this run is to test response to CTC block signal indications and track flagging situations while operating a 58-car intermodel train in 60 MPH territory. The trainees are randomly assigned to one of three variations of this run which takes one hour and 15 minutes. The third run (Generic) contributes 20% toward the total simulator examination score. The purpose of this run is to evaluate the application of specific train handling rules and methods while operating a mixed freight in planned slowdown, stop, and acceleration situations. All trainees complete this same run, which is scheduled for 60 minutes.

All three simulation runs are scored electronically based upon starting, stopping, speed control, timely whistle blows, etc. Each run has between 8 and 15 items that contribute to the total score for that run. The items are weighted in relative proportion to the importance of that item to the run as a whole and percentage of points earned is multiplied by the respective weight. The three weighted percentages are summed to create the composite score for the three runs. Simulator segments were prioritized by experienced BN engineers to establish weights for the simulation. In this validation study, the weighted sum of the simulator runs was used as one of the criterion measures.

DESCRIPTION OF THE SAMPLE

A total of 141 engineer trainees participated in the second validation study. The sample is described in Exhibit 29.

DESCRIPTION OF THE TEST AND CRITERION DATA

Exhibit 30 shows the mean test scores for the sample. Comparison with the mean scores obtained for the engineers in study 1 (see Exhibit 19) indicates that the test scores for the trainees are slightly lower on five of the six tests in the battery.

Of the 141 participants in Study 2, only 123 completed the two written tests. Scores on these tests were analyzed in terms of percentages of items correct. Scores on the General Rules test ranged from 77% to 99%, with a mean of 93.9% and a standard deviation of 4.25. Scores on the Air Brake test ranged from 63% to 99%, with a mean of 93.8% and standard deviation of 5.29. For each test, a grade of 90% or higher was the cutoff for passing the exam. Of the 123 individuals who completed these tests, 10 did not pass the General Rules Test and 8 did not pass the Air Brake test.

Simulator scores were available for 114 participants. The procedure for calculating simulator scores was slightly more complex. Two of the simulator runs--Orin and Billings–had three versions (A, B, and C) while the other one (Generic) had one version. The first issue facing us was whether or not we could treat the three versions of the Orin run and Billings run as functionally equivalent. If so, we could collapse across the A, B, and C varieties of these runs. An analysis of variance on the total percentage score means of Orin A, B, and C revealed no statistically significant differences ($F=.59$, $df=2$, 108; $p > .05$). Similarly, an analysis of variance on the Billings run means also revealed no

Exhibit 29

Second Validation Study
Description of Burlington Northern Participants

Demographics	
Number of Participants	**141**
Age Mean (SD)	**36.1 (7.29)**
Gender	**132** men **9** women
Ethnic Background	**11** African American **117** White **8** Hispanic
Years of Experience as an Engineer Mean (SD)	11.2 (6.55)

Exhibit 30

Test Mean Scores (Study 2)

Test	Mean Score	SD
Memory	22.12	7.11
Reading	28.66	5.55
Understanding Oral	26.89	4.94
Perception	13.56	3.68
Logical Reasoning	17.96	6.12
Dichotic Listening	165.25	30.49

differences ($F=.80$, $df=2,108$, $p > .05$). (Appendix A contains a brief explanation of analysis of variance). Therefore, in all subsequent analyses, we treated the A, B, and C versions of Orin and Billings runs as equivalent. We then combined the scores on these runs using the weightings which BN used to derive an overall score (as described above).

Total percentage scores for the combined score on the simulator runs ranged from 40.95 to 85.38 with a mean of 73.20 and a standard deviation of 8.27.

Both the written job knowledge tests and the simulator runs exhibited reasonable descriptive statistics and represent fairly broad differences in performance from inadequate to excellent. Furthermore, the scores on the two types of criterion measures were significantly correlated. The correlation between the simulator criterion and the General Rules Test is .21 ($p < .05$) and that between the simulator criterion and the Air Brake Test was .31 ($p < .05$). The correlation between the two written tests was .81 ($p < .01$). These results indicate that the written training test results were significantly correlated with performance on the simulator. (A brief description of the correlation coefficient is presented in Appendix A.)

VALIDATION RESULTS FOR STUDY 2

Exhibit 31 shows the correlations between each of the tests and the various criterion measures for Study 2. None of the six tests is correlated significantly with the sum of simulator runs. Reading Comprehension, Logical Reasoning, and Dichotic Listening, however, were significantly correlated with the two paper and pencil instruments administered at the end of training. In turn, the paper and pencil training tests were correlated with performance on the simulator.

Based on these findings, we conclude that the selection tests predict performance on the written job knowledge tests (as indicated by their correlation with the Air Brake and General Rules tests) and that performance on these job knowledge tests predict training performance on the simulator. Although the selection tests do not directly predict the performance component of training, they predict the knowledge component of training. In other words, the selection tests predict the knowledge component of training and knowledge component of training predicts simulator performance. There is, however, no direct relationship between test scores and performance on the simulator.

The findings of Study 2 are consistent with the results of prior research indicating that cognitive abilities are critical for successful training. Hunter (1983) sheds insight on the links between cognitive ability tests, training performance, and subsequent job performance. Hunter's analysis of 14 validation studies indicates that cognitive abilities influence the extent to which an individual masters the knowledge required for job performance. Job knowledge then mediates the relationship between cognitive abilities and job performance. On relatively routine jobs with fairly constant KSAs, such as the locomotive engineer job, cognitive ability tests scores may not be directly related to job performance, but rather indirectly related via job knowledge.

The next analysis concerned the identification ,of the set of tests which best predict the written training tests. Seldom is it necessary to include all of the tests which have been tried out in the preliminary battery. In order to select the combination of ability tests which best predicted the written training tests, we analyzed

Exhibit 31

Correlations Between Tests and Training Criteria

Tests	Combined Simulator Score	General Rules	Airbrake
Memory	.05	.16	.17
Reading	.12	.30*	.25*
Perception	.07	.09	.09
Understanding Oral	.04	.17	.16
Logical Reasoning	.02	.29*	.28*
Dichotic Listening	-.07	.23*	.23*

the results of a stepwise multiple regression predicting the sum of the two written tests. (The scores on Air Brake and General Rules tests were standardized so that each test would have equal weighting in the sum.)

In general, when a stepwise multiple regression shows that a test (or tests) does not add significantly to prediction, the finding arises either because the test is not a valid predictor or because the criterion variance is predicted by another test in the battery which is highly correlated with that test. Because of the high correlations between all of the cognitive tests in the battery (see Exhibit 21), we anticipated that not all these tests would be significant predictors in the multiple regression.

As Exhibit 32 shows, the best predictor of performance on the training tests is the Reading test. The only other test which adds significantly to the prediction is the Dichotic Listening test. The multiple regression of these two tests predicting the training test scores is .41 ($p < .001$). This result predicates that the Reading and Dichotic Listening Tests together effectively predict performance on the written training test. This test, then, differentiates individuals who are more likely from those less likely to perform successfully in training.

Exhibit 32

Results of the Multiple Regression Predicting Performance on the Training Tests

Tests	Multiple R	R Square	Change in R Square
Reading	.35	.12246	.12246**
Dichotic Listening	.41	.16697	.04451*

<u>Notes:</u>
** $p < .01$

RECOMMENDATIONS

RECOMMENDATIONS FOR IMPLEMENTATION

What implications do these results have for the usefulness of the cognitive ability tests for selecting engineer trainees? First, three of the tests--Reading, Logical Reasoning, and Dichotic Listening--predict scores on written training exams. Two of these tests, the Reading and Dichotic Listening Tests, together efficiently predict performance on the written training tests. These findings are consistent with extensive previous research demonstrating that cognitive abilities are important predictors of training success. Because training of locomotive engineers is necessary for safe and efficient train handling, is legally mandated, is time consuming and expensive, it would benefit the railroads to identify those applicants who are most likely to successfully complete training.

The cognitive ability tests do indeed identify applicants who are more Likely to successfully complete training. We, therefore, recommend that railroads seriously consider using the Reading and Dichotic Listening tests to select applicants for engineer training. URC also recommends use of a physical exam to assess the applicant's ability to recognize colors, to reach with hands and arms, and to judge distance. URC also recommends that the railroads administer the Logical Reasoning test, but not use it for selection, so that its effectiveness can be later assessed.

The research results indicate that the selection tests can be used to identify engineer trainees most likely to pass written training tests. Why are these tests useful for a railroad? These tests measure the KSAs of reading and focusing attention which job experts identify as important for performing critical engineer tasks. These tests can reduce the number of individuals who fail training. In addition, these tests are especially useful when there are many applicants for places in engineer training classes.

RECOMMENDATIONS FOR ADDITIONAL RESEARCH

Although the results of the second validation study support the validity of the test battery for use in selecting trainees, the study was undertaken in only one railroad. We recommend that other railroads commence validation studies. Either individual railroads can perform a validation study or a group of railroads can work together in a consortium.

In addition, we also strongly recommend that the railroads consider developing and validating other tests which might be useful for predicting both simulator performance and job performance. What types of tests might be useful for this purpose? Research by Ackerman and Fleishman can be used to identify such ability measures. Ackerman (1992) presents a model of complex skill acquisition which indicates that at different stages of skill acquisition, different abilities predict task performance. Ackerman proposes that there are three phases of skill acquisition:

1. The cognitive phase of skill acquisition which is associated with demands on general cognitive reasoning. Measures of cognitive abilities predict performance during the acquisition or learning phase of performance.

2. During the associative phase of skill acquisition, greater demands are placed on perceptual speed abilities. Measures of perceptual speed predict performance when the person has greater experience practicing the skill but has not yet mastered the skill.

3. The autonomous phase of skill acquisition is associated with demands on perceptual/psychomotor abilities. Measures of perceptual/psychomotor ability (e.g., reaction time) are more predictive of performance when the skill has been learned.

Ackerman's model is consistent with the extensive research undertaken by Fleishman (1967, 1972, 1975) which indicates that early in practice, general (i.e., cognitive) abilities are better predictors of performance, while as practice continues, task performance is unrelated to the broad, general abilities. During this later phase of skill acquisition, psychomotor abilities predict task performance.

The research by both Ackerman and Fleishman helps to explain why the cognitive abilities used in this study predicted the learning phase of performance but not the more skilled aspects of performance. Their research also suggests that psychomotor tests might be predictive of both simulator and job performance. In an extensive review of the literature, McHenry and Rose (1986) conclude that psychomotor tests have been successfully used to predict job performance in a number of jobs. Measures of multilimb coordination, hand-eye coordination, rate control and arm-hand steadiness may be most relevant to the engineer job.

There is a problem, however, with the use of psychomotor tests using apparatus for test administration. Perhaps the most serious disadvantage of apparatus tests is the lack of standardization. Two units of the same apparatus may be quite different with respect to their actual operation. In the last 10 years a number of psychomotor tests have been adapted for the computer. Computerized tests have some advantages over apparatus tests: they are more reliable, less likely to break down, and reduce test administration costs.

URC did not use these tests in the test battery because the railroads reviewing the initial test plan concluded that computers were not consistently available for test administration. Currently, this may be less a problem than it was in the 1980's.

Ackerman's model also suggests that tests of perceptual abilities can be useful in predicting job performance. The test battery we developed and used included one such test which did not prove to predict job performance. Consideration of other perceptual ability tests (like reaction time) should be considered. However, we think that psychomotor test offers the most promise for the prediction of simulator and job performance.

RECOMMENDATIONS FOR VALIDATION RESEARCH

We recommend that the railroads undertake additional validation research on both the current battery and the battery with the inclusion of the Logical Reasoning test, a psychomotor test and perhaps a perceptual ability test. We recommend that applicants be given the tests prior to being hired then followed through training and on the job to determine their job performance over a specified period of time. The validation design proposed for these tests is fairly straightforward. Implementation of the design requires the following five steps:

1. Give job applicants the three tests.
2. Hire the required number of applicants as locomotive engineer trainees.
3. Obtain training tests scores for the trainees. If simulator performance data are available, include such data.
4. Obtain performance data for the trainees six months after they are on the job
5. Analyze the data.

Although each railroad will establish its own procedure for determining which applicants will be given these tests, test scores for all applicants who take the battery should be kept on file. In addition to test scores, some basic demographic data for each applicant should be kept. These data should include name, age, ethnic background, sex, and prior company experience.

All applicants hired for the job are automatically used for the validation study. Training performance data on the trainees must be collected. The railroad can use its own training tests. We also recommend that the railroads use a standard written engineer training test developed for this project by Ralph and Lyn Haber, which is presented in Appendix E. The test is a 95 item multiple choice test pertaining to train handling procedures of over-the-road and through freight trains. The test was developed in consultation with engineers and has been reviewed by both railroads and the FRA. If the railroads use a simulator to evaluate training performance, we strongly recommend that all the trainees take one or two standard runs and that scores on these runs be retained.

After completing training, the new engineers should be followed for six months and evaluated on their job performance. If appropriate, the supervisory rating developed in this project (see Appendix C) could be used if the road foremen gets several opportunities to observe and evaluate engineers. When data for 100 engineers have been collected, the data can be analyzed. Since few railroads will hire that many engineers in a reasonable period of time, we recommend that several railroads work together in a consortium study. By pooling the data across several companies, such a validation can be conducted and data analyzed much earlier than if a company had to wait until enough individuals were hired to result in reliable analyses. We should note that if a consortium study is planned, it is important to collect training and job performance data using the same forms in all the participating railroads.

Several sets of analyses should be conducted as part of this validation study:

- Correlations among the selection tests.
- Correlations between scores on the selection tests and scores on the training tests.

- Correlations between scores on the selection tests and scores on the ratings of job performance.
- Correlations between scores on the training tests and scores on the ratings of job performance.
- Correlations between scores on the selection tests and scores on the simulator runs.

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Appendix A. Explanation of Statistical Terms

Analysis of Variance is a procedure used to determine the statistical significance of the **differences** between the mean scores in three or more groups. For example, analysis of variance can be used to determine if the mean math achievement scores differ among three classes.

Correlation Coefficient is value indicating the association between two variables. The correlation coefficient ranges from -1.00 through +1.00. The **size** and sign of the correlation indicates the relationship between the variables. The closer the relationship between the variables, the greater than size of the correlation coefficient (the closer in approximates +1.00 or -1.00). The sign (+ or -) of the correlation coefficient indicates whether the variables are positively related (a positive correlation) or negatively related (a negative correlation). If two variables are positively correlated, then higher scores on one variable are associated with higher scores on the second variable. If two variables are negatively correlated, then higher scores on one variable are associated with lower scores on the second variable.

Factor Analysis is a statistical technique used to determine the grouping of a set of variables. In using factor analysis, a researcher can determine whether there are underlying factors which account for the relationship among the variables. The result of factor analysis is a smaller set of variables, or factors. The correlation between the original variables and the factors is called the loading. The pattern of loadings can be used to explain the nature of the factor. For example, if only reading tests have high loadings on a factor, then we could interpret this factor in terms of reading ability. Principal components analysis is similar to factor analysis in that it is a technique to reduce the number of variables and make the relationships among the variables more understandable.

Intraclass coefficientis a statistic which indicates the inter-rater reliability or agreement in ratings. It is essentially an average intercorrelation between the ratings from all pairs of raters.

Multiple Regression is a statistical test which correlates one characteristic with a set of other characteristics. For example, a researcher might be interested whether achievement on a math test can be predicted by the combination of intelligence test scores, socio-economic status, and attitudes about math.

Reliability refers to the consistency of scores obtained by the same individuals when retested with the same test or with a different set of equivalent items in two tests. CoefficientAlpha is one estimate of reliability. It indicates the consistency of the subjects' responses to all of the items in a test. It is a measure of the degree to which all the items measure one characteristic.

Standard Deviation is a statistic which shows how much the scores are spread out or distributed around the mean. The larger the standard deviation, the more spread out are the scores.

Statistical Significance Research is typically undertaken with a sample, rather than with a population of individuals. Having undertaken the research and analyzed the data, the researcher is left to ask how likely is it that the observed differences between groups or association between variables in the sample where there are no actual differences between the groups or not association in the population. In order to reject the explanation of chance, or what is called the null hypothesis, the data from the study is compared to the distribution of results that would arise by chance alone. If the research results are very **unlikely** to have occurred by chance (1 out of 20 times is the usually used), then the researcher concludes that the results are not a chance phenomenon. The term "$p < .05$" is used to represent the finding that these data could have occurred with a probability of less than .05 or 1/20. This term indicates that the results are statistically significant.

Appendix B. KSA List

Understanding Printed/Written Material

1. **Reading** simple words, such as position signs on machine equipment (e.g., "On/Off", or "Start/Stop").
2. Reading <u>simple</u> sentences, such as posted signs or directions (e.g., "Keep boxes out of aisles").
3. **Reading** complex sentences, such as written material on work tickets or printed material on containers (e.g., "This material may explode if it gets wet").
4. Reading paragraphs which describe a thing or event <u>**or**</u> present multiple instruction in sequence, such as instructions in operating.
5. Reading computer print-outs, computer screens, or other material that is **primarily numerical** in nature.
6. Memorizing and recalling **specific** information learned from printed materials.

Performing Calculations

7. Adding and/or subtracting whole numbers.
8. Multiplying and/or dividing whole numbers.
9. Adding, subtracting, multiplying, and/or dividing fractions.
10. Adding, subtracting, multiplying, and/or dividing involving decimals and/or percentages.
11. Using a simple formula to solve for an unknown.

Understanding Oral Communications

12. Coordinating work with co-workers through **conversation/discussion** where effectiveness depends on understanding others.
13. Understanding oral instructions or work procedures information provided by supervisors or others.
14. Receiving on-the-job **training** provided by supervisor or others.
15. Participating in group meetings or training sessions where effectiveness depends on understanding others.

Making Oneself Understood Orally

16. Coordinating work with co-workers through **conversation/discussion** where effectiveness depends upon being understood.
17. Providing routine oral status or progress reports to supervisor or others, in person, by phone, or by radio.
18. "Breaking in" a new employee or otherwise instructing others.
19. Making informal reports to small groups.

Making Oneself Understood in Writing

20. Entering simple information or data on forms such as: recording temperature, pressure, thickness, quality, or number or errors.

21. Copying information (from print-outs, reports, etc.) into hand-written form.
22. Preparing simple records, such as: work reports, logs, or information for next shift.
23. Preparing written reports, such as: equipment malfunctions, performance results, or accident data.
24. Entering information by computer terminal, typewriter, or other keyboard or data entry device.

Understanding Graphic Information

25. Reading simple blueprints, sketches, diagrams, or shop drawings.
26. Reading numerical information in graphic form.

Exercising Mechanical Insight

27. Understanding mechanical relationships in practical situations, such as: understanding leverage, pulleys, or the direction gear arrangements turn.
28. Understanding the relationship of physical objects to one another in order to visualize a number of such objects acting together.
29. Visualizing objects in three dimensions.
30. Making visual comparisons between objects or pictures or diagrams.

Making 'Estimates

31. Estimating weight or objects.
32. Estimating size of large objects or areas relative to other objects or areas, such as: when parking a car or moving a crate between machines.
33. Estimating the speed or distance of moving objects or parts.

Making Choices and/or Solving Problems

34. Making choicesldecisions in which the risks or consequence are slight, such as: sorting materials or parts.
35. Making choicesldecisions affecting the security or well-being of others and/or which involve serious risk or consequences.
36. Solving problems involving limited options by applying common sense understandings, such as: selecting the correct tool for a job.
37. Solving problems involving a few relatively concrete options or variables by applying principles or methodologies, such as: troubleshooting malfunctions or breakdowns in familiar equipment.

Making Visual or Auditory Discriminations

38. Discriminating visual detail at distances within arm's reach.
39. Discriminating fine visual detail at distances within arm's reach.
40. Recognizing colors, such as: light signals, containers, or electrical parts.

41. Judging distance **from** observer to objects **and/or** between objects.
42. Recognizing changes in sounds.
43. Recognizing audible signals, such **as:** bells, whistles, or sirens.
44. Recognizing objects or signals under conditions of limited visibility, such **as:** seeing signals in fog or recognizing a sound in the presence of other noises.
45. Memorizing and recalling visual information such as maps or scenes.
46. Maintaining attention to a task over long periods of time.

Using Hands in Work Activity

47. **Reaching** - extending **hand(s)** and **arm(s)** in any direction.
48. Seizing, holding, grasping, turning, or otherwise working with **hand(s)** when **fingers** are not involved.

Making Gross Body Requirements

49. Stooping - bending body downward and forward by bending spine at waist.

Climbing or Balancing

50. Ascending **and/or** descending ladders, stairs, scaffolding, or poles, using feet and arms or hands.
51. Maintaining body equilibrium to prevent falling when walking, standing, crouching, or running on irregular, slipper, or erratically moving surface.

Appendix C. Engineer Rating Form

TRAIN HANDLING AND OPERATING PROCEDURES OBSERVATION FORM

Instructions

Use this form to record how the engineer you are riding with performed during the trip. The form is built around several situations in which an engineer could be expected to demonstrate train handling proficiency, for example, starting or stopping the train. For each of the situations that the engineer encountered during the trip, record your observation of the engineer's performance by placing check marks in front of all statements that reflect what the engineer did or what happened to the train as a result of the engineer's actions.

After making these ratings, make an evaluation of the engineer's performance in that situation. Use the scale at the bottom of each page to indicate your appraisal of the performance that you observed during the trip.

Please review this form before the trip in order to familiarize yourself with the ratings you will be making. Taking notes during the trip may be helpful. **Fill out the rating form immediately after the trip to ensure the ratings are accurate.**

Engineer: ______________________________

Rater: ______________________________

Date of Trip: ______________________________

Duration of Observation: ______________________________

Train Symbol: ______________________________

Train Consist (No. of locomotives,
loads and empties): ______________________________

Special Train Makeup (if appropriate): ______________________________

Territory: ______________________________

Rate the diffuculty of the trip (considering the train consist, territory, weather, time of the day, and other factors.)

______	______	______	______	______
easy		**average**		**difficult**

Prestart

		Did the engineer follow acceptable procedures?		
		YES	NO	Not observed or Not applicable
1.	Reports to work on time and is fit for service.	___	___	___
2.	Wears proper clothing and footwear.	___	___	___
3.	Has and reviews required documents (time table, train bulletin, track warrants, general orders, etc.)	___	___	___
4.	Performs locomotive inspections.	___	___	___
5.	Checks for safety equipment.	___	___	___
6.	Performs radio check.	___	___	___

Based on observations **during** this trip, my evaluation of the engineer's performance for **Prestart** is checked below:

___	___	___	___	___	___
Not observed or not applicable	Unsatisfactory Does not **perform** this part of the job at a competent **level**	Marginal: Performs this part of the job at a minimally competent level	Satisfactory **Competently** performs this part of the job	**Superior:** **Performs** this part of the job at a more than competent **level**	Outstanding **Performance exceeds requirements** for this part of the job

Rules Compliance

		Did the engineer follow acceptable procedures? YES	NO	Not observed or Not applicable
1.	Uses bell, whistle, headlight.	___	___	___
2.	Verifies speedometer accuracy.	___	___	___
3.	Acknowledges and complies with fixed signals.	___	___	___
4.	Speed compliance.	___	___	___
5.	Reports signal malfunctions to dispatcher.	___	___	___
6.	Reports defective track conditions.	___	___	___
7.	Inspects train while moving.	___	___	___
8.	Observes passing trains and reports defects.	___	___	___
9.	Fills out necessary paperwork.	___	___	___
10.	Communicates instructions and information with others.	___	___	___
11.	Uses proper radio procedure.	___	___	___
12	Performs air brake tests, as required.	___	___	___
13.	Protects the train, as required (e.g., if train derails, ensures adjacent track is protected.)	___	___	___
14.	Observes other crew members for proper job performance.	___	___	___
15.	Other rules, as applicable (specify).	___	___	___

Based on observations during this trip, my evaluation of the engineer's performance for Rules Compliance is checked below

___	___	___	___	___	___
Not observed or not applicable	**Unsatisfactory. Does not perform this part of the job at a competent level**	**Marginal: Performs this part of the job at a minimally competent level**	**Satisfactory. Competently performs this part of the job**	**Superior: Performs this part of the job at a more than competent level**	**Outstanding Performance exceeds requirements for this part of the job**

Operation of Equipment

Did the engineer follow acceptable procedures?

		YES	NO	Not observed or Not applicable
1.	When alarm sounds, takes action to identify problem.	___	___	___
2.	Isolates a malfunctioning unit, as required.	___	___	___
3.	Resets devices, as required.	___	___	___
4.	Restarts the engine, as required.	___	___	___
5.	Notifies proper authorities of equipment malfunctions.	___	___	___
6.	Writes proper work reports.	___	___	___
7.	Properly conditions unit for lead or trail including **connecting/disconnecting** hoses and cables, and positions other controls when picking up or setting out units.	___	___	___
8.	Monitors gauges and devices **(including** end of train device) and takes corrective action when required.	___	___	___
9.	Drains unit during cold weather operations.	___	___	___
10.	Recognizes if locomotive is not performing properly.	___	___	___

Based on observations during this trip, my evaluation of the engineer's performance for Operation of Equipment is checked below:

Not observed or not applicable	**Unsatisfactory:** Does not perform this part of the job at a competent level	**Marginal:** Performs this part of the job at a minimally competent level	**Satisfactory:** Competently performs this part of the job	**Superior:** Performs this part of the job at a more than competent level	**Outstanding:** Performance exceeds requirements for this part of the job

Starting the Train

	Did the engineer follow acceptable procedures? YES	NO	Not observed or Not applicable
All Conditions			
1. Properly charges brake system before moving.	___	___	___
2. Allows enough time for brakes to fully release before starting the train.	___	___	___
3. Uses independent brake valve to control locomotive acceleration, when required.	___	___	___
4. Reacts to wheel slippage.	___	___	___
5. Applies lead truck sanding on lead locomotive if required.	___	___	___
6. Advances throttle one notch at a time while observing load current meter in such a manner to provide smooth operation under proper slack control.	___	___	___
Ascending Grade			
7. Advances throttle before releasing automatic and independent brakes.	___	___	___
8. On heavier grade, sets automatic brake and backs locomotive into train to bunch it. Release brakes and starts forward movement so rear cars do not roll back.	___	___	___
Descending Grade			
9. After releasing automatic brake, gradually releases independent brake until entire train is moving.	___	___	___
10. With dynamic brake applied, gradually releases independent brake to keep slack bunched until dynamic brake becomes effective.	___	___	___

Based on observations during this trip, my evaluation of the engineer's performance for Starting the Train is checked below:

___	___	___	___	___	___
Not observed or not applicable	Unsatisfactory: Does not perform this pan of the job at a competent level	Marginal: Performs this pan of the job at a minimally competent level	Satisfactory Competently performs this part of the job	Superior: Performs this pan of the job at a more than competent level	Outstanding: Performance exceeds requirements for this pan of the job

Accelerating

Did the engineer follow acceptable procedures?

		YES	**NO**	**Not observed or Not applicable**
1.	Advances throttle one notch at a time as load current meter stops increasing or begins dropping.	___	___	___
2.	Reduces throttle at indication of wheel slippage.	___	___	___
3.	Gradually reduces dynamic brake while observing load meter.	___	___	___
4.	Does not accelerate until brake is released throughout the train.	___	___	___

Based on observations during this trip, my evaluation of the engineer's performance for Accelerating is checked below:

___	___	___	___	___	___
Not observed or not applicable	Unsatisfactory: Does not perform this part of the job at a competent level	Marginal: Performs this part of the job at a minimally competent level	Satisfactory: Competently performs this part of the job	Superior: Performs this part of the job at a more than competent level	Outstanding: Performance exceeds requirements for this part of the job

Controlling Speed

Did the engineer follow acceptable procedures?

	YES	**NO**	**Not observed or Not applicable**
All Conditions			
1. Varies throttle movements slowly, only one notch at a time.	___	___	___
2. Adjusts dynamic brakes slowly, while observing load meter.	___	___	___
3. Keeps speed and train forces fairly constant with dynamic brake adjustments.	___	___	___
4. Uses automatic brake to supplement dynamic brake, when required.	___	___	___
5. Maintains speeds required in curves, turnouts and restricted zones, without building up excessive train forces.	___	___	___
6. Uses retainers as needed.	___	___	___
7. Where possible, adjusts throttle for maintaining speed.	___	___	___
8. Uses dynamic brake rather than automatic brake, where practical.	___	___	___
9. Uses cycle braking to control speed.	___	___	___
10. Makes initial automatic brake service reduction plus additional reductions, as required (including blended braking).	___	___	___
Slack Bunched			
11. Uses maximum permissible dynamic brakes before applying automatic brake (or blended brakes).	___	___	___
12 Releases automatic brake in order to maintain desired speed.	___	___	___

		Did the engineer follow acceptable procedures?		
		YES	**NO**	**Not observed or Not applicable**
13.	Keeps train bunched using dynamic or independent brake.	___	___	___
<u>Slack Stretched</u>				
14.	Gradually reduces throttle as automatic brake becomes effective, while observing load meter.	___	___	___
15.	Uses throttle to keep train stretched.	___	___	___
16.	Releases automatic brake before reaching desired speed.	___	___	___
17.	Does not advance throttle until brakes are released.	___	___	___

Based on observations during this trip, my evaluation of the engineer's performance for Maintaining Speed is checked below:

___	___	___	___	___	___
Not observed or not applicable	**Unsatisfactory Does not perform this part of the job at a competent level**	**Marginal. Performs this part of the job at a minimally competent level**	**Satisfactory Competently performs this part of the job**	**Superior. Performs this part of the job at a more than competent level**	**Outstanding. Performance exceeds requirements for this part of the job**

Negotiating Cresting Grade

Did the engineer **follow** acceptable **procedures?**

		YES	NO	Not observed or Not applicable
1.	Has train moving at an appropriate speed at crest.	___	___	___
2.	Reduces throttle as locomotive crests grade in order to maintain speed and reduce coupler forces in train at crest.	___	___	___
3.	Controls speed of train by further reductions of throttle.	___	___	___
4.	Uses dynamic brake to control speed of train in descent. Transition to dynamic brake is made smoothly.	___	___	___
5.	Use automatic brake to supplement dynamic brake.	___	___	___
6.	Makes initial automatic brake service reduction plus additional reductions as required.	___	___	___

Based on observations during this trip, my evaluation of the engineer's performance for Negotiating a Cresting Grade is checked below

___	___	___	___	___	___
Not observed or not applicable	**Unsatisfactory:** Does not perform this part of the job at a competent level	**Marginal:** Performs this part of the job at a minimally competent level	**Satisfactory:** Competently performs this part of the job	**Superior:** Performs this part of the job at a more than competent level	**Outstanding:** Performance exceeds requirements for this part of the job

Stopping Train

		Did the *engineer* follow acceptable procedures?		
		YES	NO	Not **observed** *or* Not applicable
Slack Stretched				
1.	Maintains sufficient throttle to keep train stretched.	___	___	___
2.	Makes initial brake **service** reduction plus additional reductions as required.	___	___	___
3.	Reduces throttle one notch at a time, while observing load meter.	___	___	___
4.	Train decelerates smoothly and efficiently to stop at desired location.	___	___	___
5.	Applies independent brakes when stopped.	___	___	___
6.	Places throttle in idle at appropriate time.	___	___	___
7.	Makes **final** automatic brake application and keeps brake applied while stopped.	___	___	___
Slack Bunched				
8.	Uses dynamic brake as primary braking source.	___	___	___
9.	When automatic brakes are needed to supplement dynamic brake, makes initial brake reduction plus additional reductions as required.	___	___	___
10.	Train decelerates smoothly and efficiently to stop at desired location.	___	___	___
11.	Makes **final** automatic brake application.	___	___	___
12.	Applies independent brake as dynamic brake fades.	___	___	___

Based on observations during this trip, my evaluation of the engineer's performance for Stopping Train is checked below:

Not observed or not applicable	**Unsatisfactory:**	**Marginal:**	**Satisfactory:**	**Superior:**	**Outstanding:**
	Does not perform this pan of the job at a competent level	**Performs this part of the job at a minimally competent level**	**Competently performs this pan of the job**	**Performs this pan of the job at a more than competent level**	**Performance exceeds requirements for this pan of the job**

Switching

Did the engineer follow acceptable procedures?

		YES	**NO**	**Not observed or Not applicable**
1.	Starts releasing independent brake and applying light power until slack is adjusted and all cars in block are moving.	___	___	___
2.	Speed is appropriate for switching conditions.	___	___	___
3.	Bunches and stretches slack smoothly.	___	___	___
4.	Makes moves at consistent speed so crew can anticipate stopping and starting distances.	___	___	___
5.	Care is used in applying the independent brake to avoid wheel slide.	___	___	___
6.	Observes and responds to hand or radio signal.	___	___	___

Based on observations during this trip, my evaluation of the engineer's performance for Switching is checked below

Not observed or not applicable	Unsatisfactory: Does not perform this part of the job at a competent level	Marginal: Performs this part of the job at a minimally competent level	Satisfactory: Competently performs this part of the job	Superior. Performs this part of the job at a more than competent level	Outstanding Performance exceeds requirements for this part of the job

Other Comments

Appendix D. Scatterplot of Validation Correlations for Study I

NOTES

Criteria:

SUMFS: Sum of the Dimension Ratings

SUMFO: Sum of the Behavior Ratings

Tests:

Memory: Memory

Reading: Reading Comprehension

Percept: Perception

Listen: Understanding Oral Instructions

Logic: Logical Reasoning

Dichotic: Dichotic Listening

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                       PLOT OF SUMFS WITH MEMORY
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  °                                                                 °
66Ç                                                                 û
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  °                                  1                              °
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  °                  1 1   1       1 2               1              °
  °                    1 1       2                                  °
54Ç                            1         1       1                  û
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  °                      1   1               1                      °
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    7.5      12.5      17.5      22.5      27.5      32.5      37.5
          10        15        20        25        30        35

                                MEMORY
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2 cases plotted.

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                              PLOT OF SUMFS WITH READING
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      11.25     15.75     20.25     24.75     29.25     33.75     38.25
            13.5        18      22.5        27      31.5        36

                                       READING

122 cases plotted.
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                       PLOT OF SUMFS WITH PERCEPT
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5.25       8.75     12.25     15.75     19.25     22.75     26.25
         7      10.5        14      17.5        21      24.5

                                PERCEPT

2 cases plotted.
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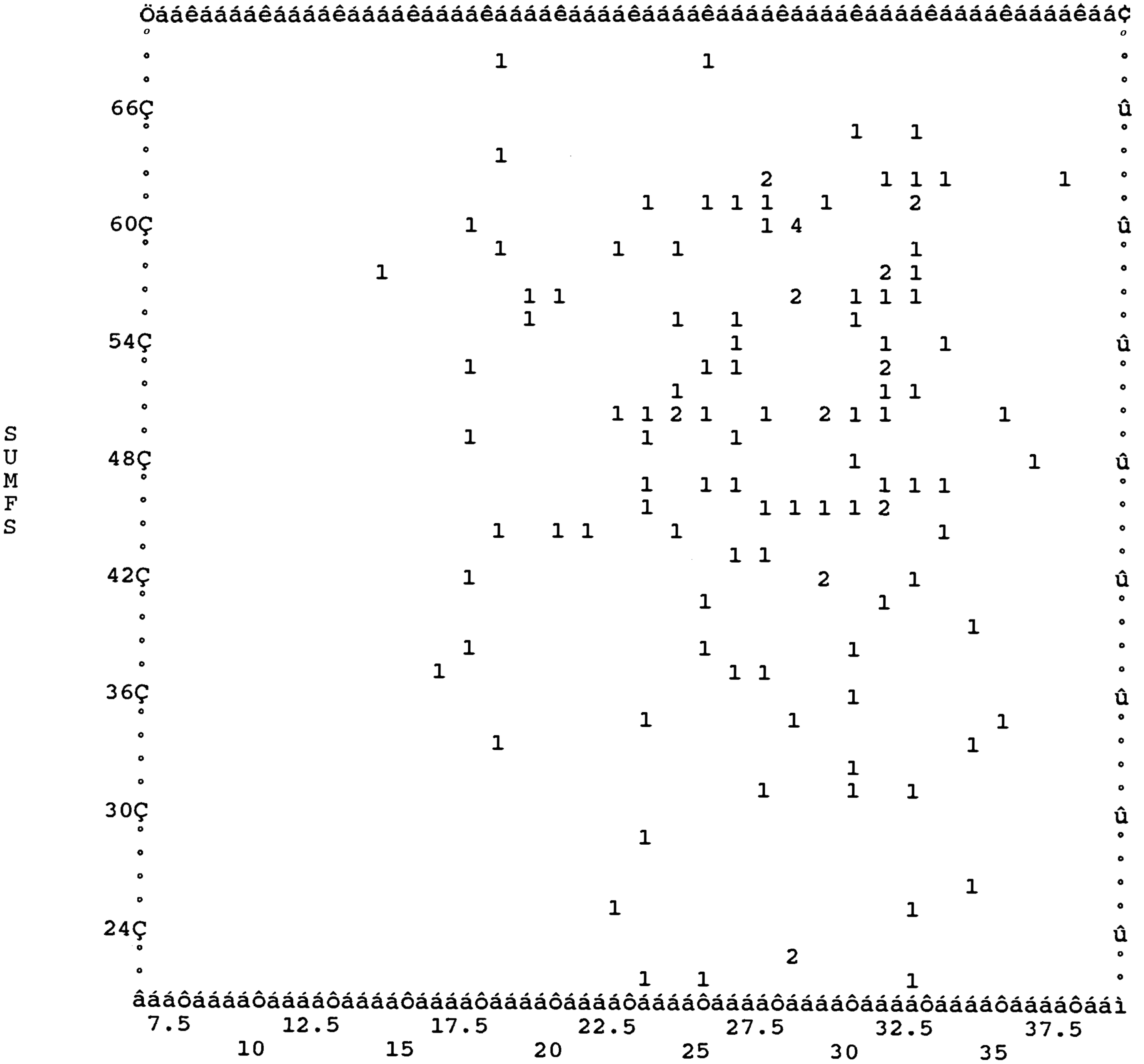
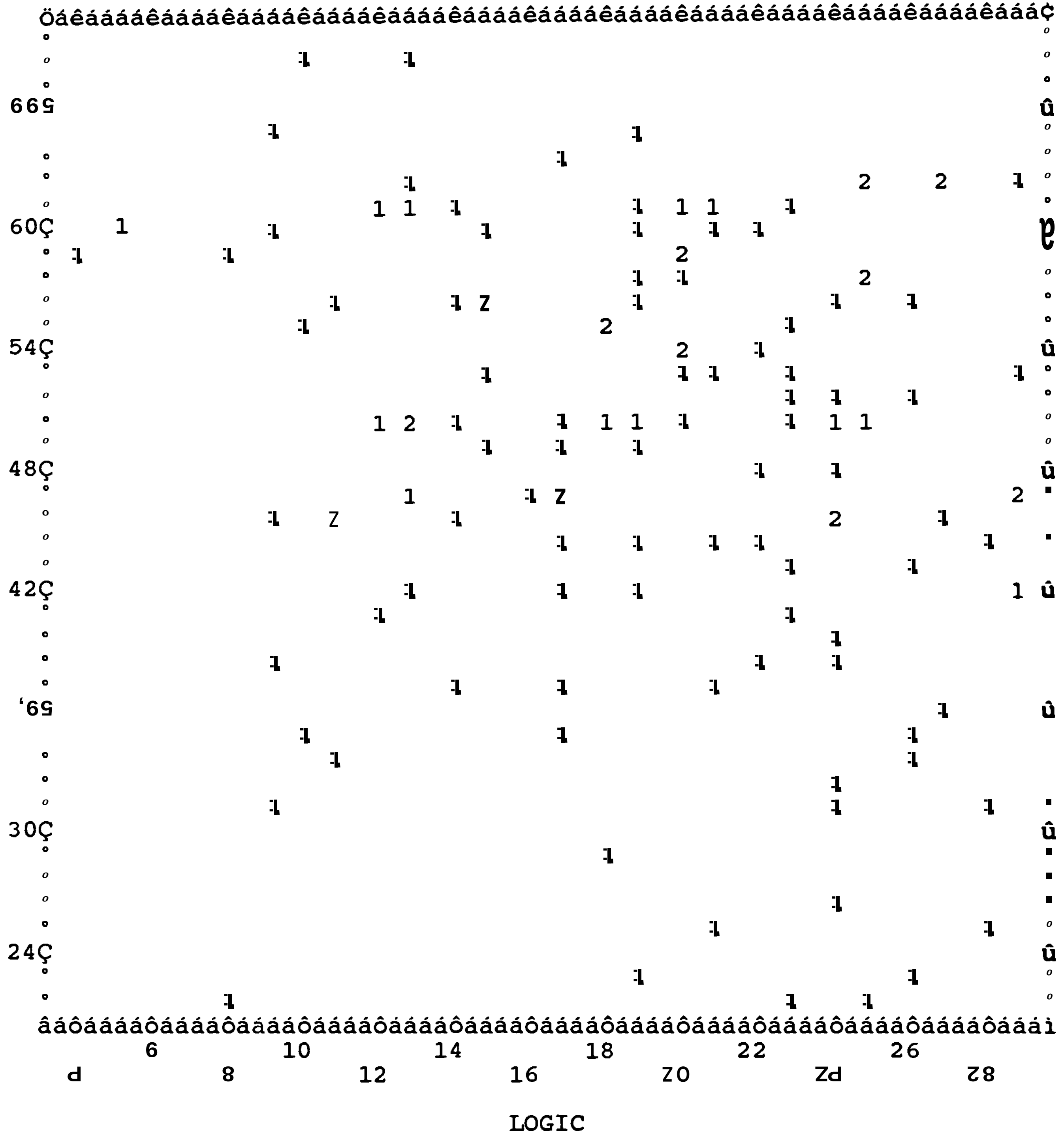
PLOT OF SUMFS WIZH LISTEN



122 cases plotted.

PLOT OF SUMFS WITH LOGIC



2 cases plotted.

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                                PLOT OF SUMFS WITH DICHOTIC
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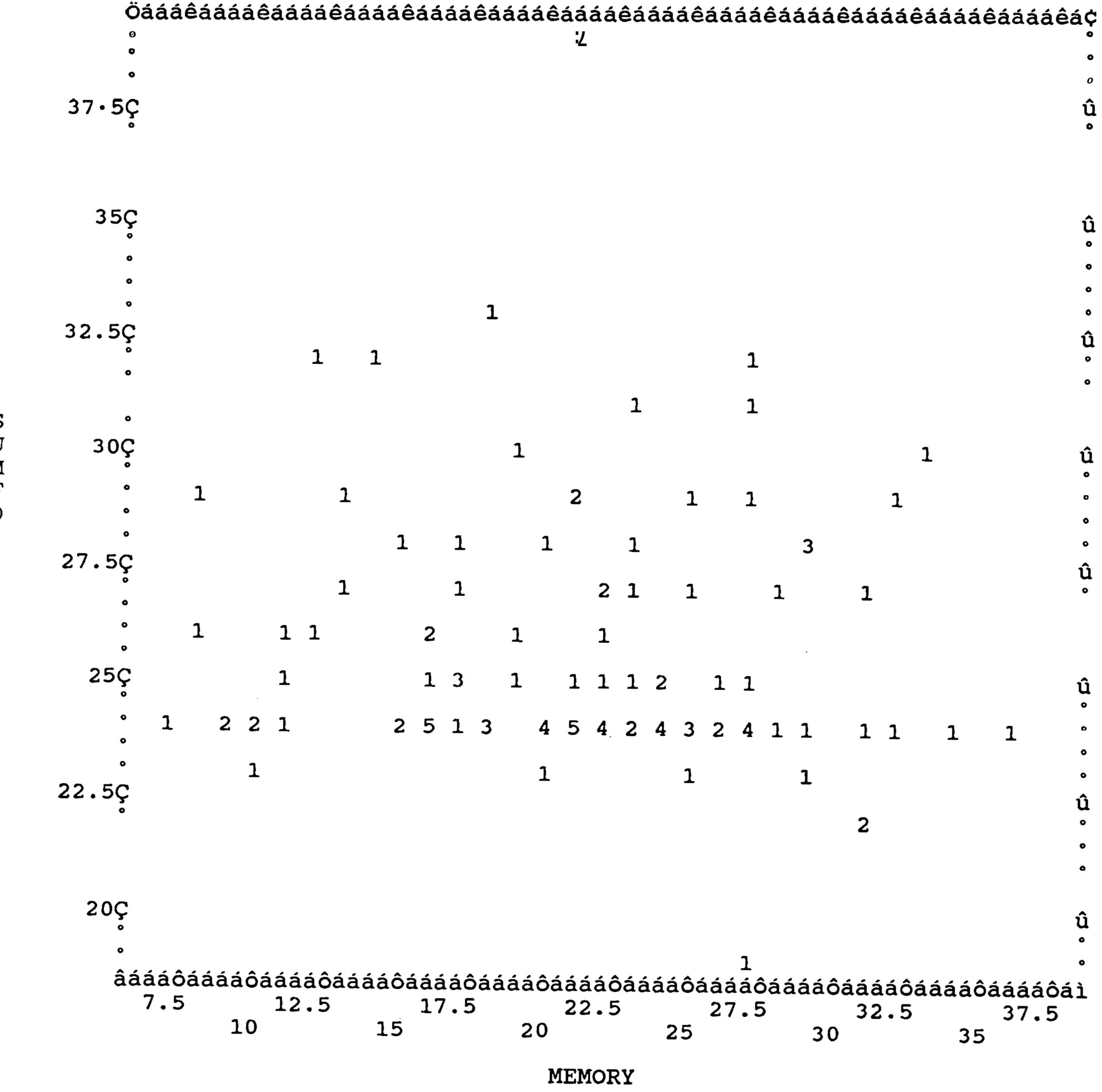
                 15        45        75       105       135       165
             0        30        60        90       120       150       180

                                        DICHOTIC

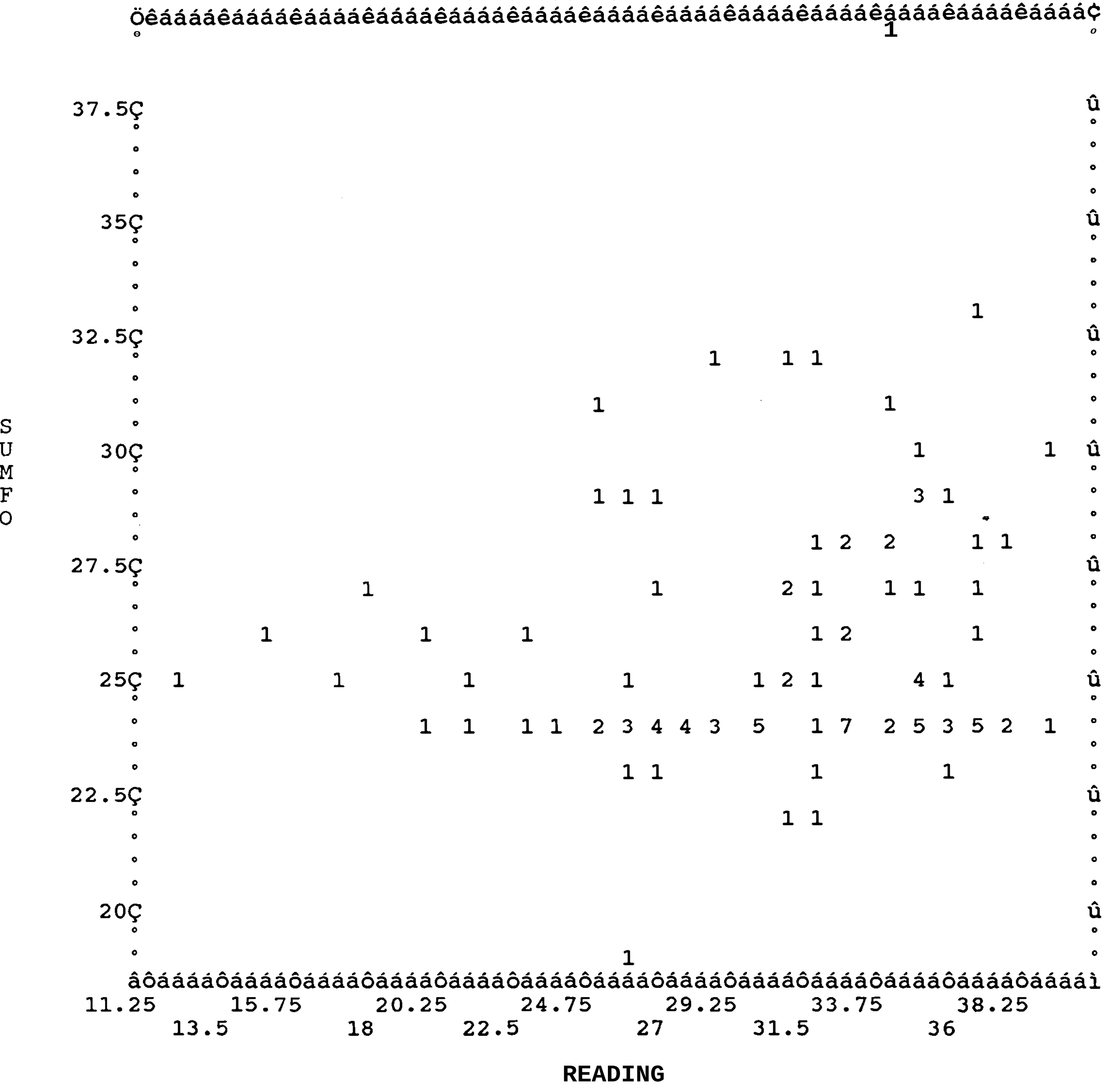
122 cases plotted.
```

PLOT 09 SUMFO WITH MEMORY



9 cases plotted.

PLOT OF SUMFO WITH READING



09 cases plotted.

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                              PLOT OF SUMFO WITH PERCEPT
         ÖáêááááêááááêááááêááááêááááêááááêááááêááááêááááêááááêááááêááááêáááÇ
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        5.25      8.75     12.25     15.75     19.25     22.75     26.25
                7      10.5        14      17.5        21      24.5

                                       PERCEPT
109 cases plotted.
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                              PLOT OF SUMFO WITH LISTEN
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          7.5      12.5      17.5      22.5      27.5      32.5      37.5
                10        15        20        25        30        35

                                       LISTEN

109 cases plotted.
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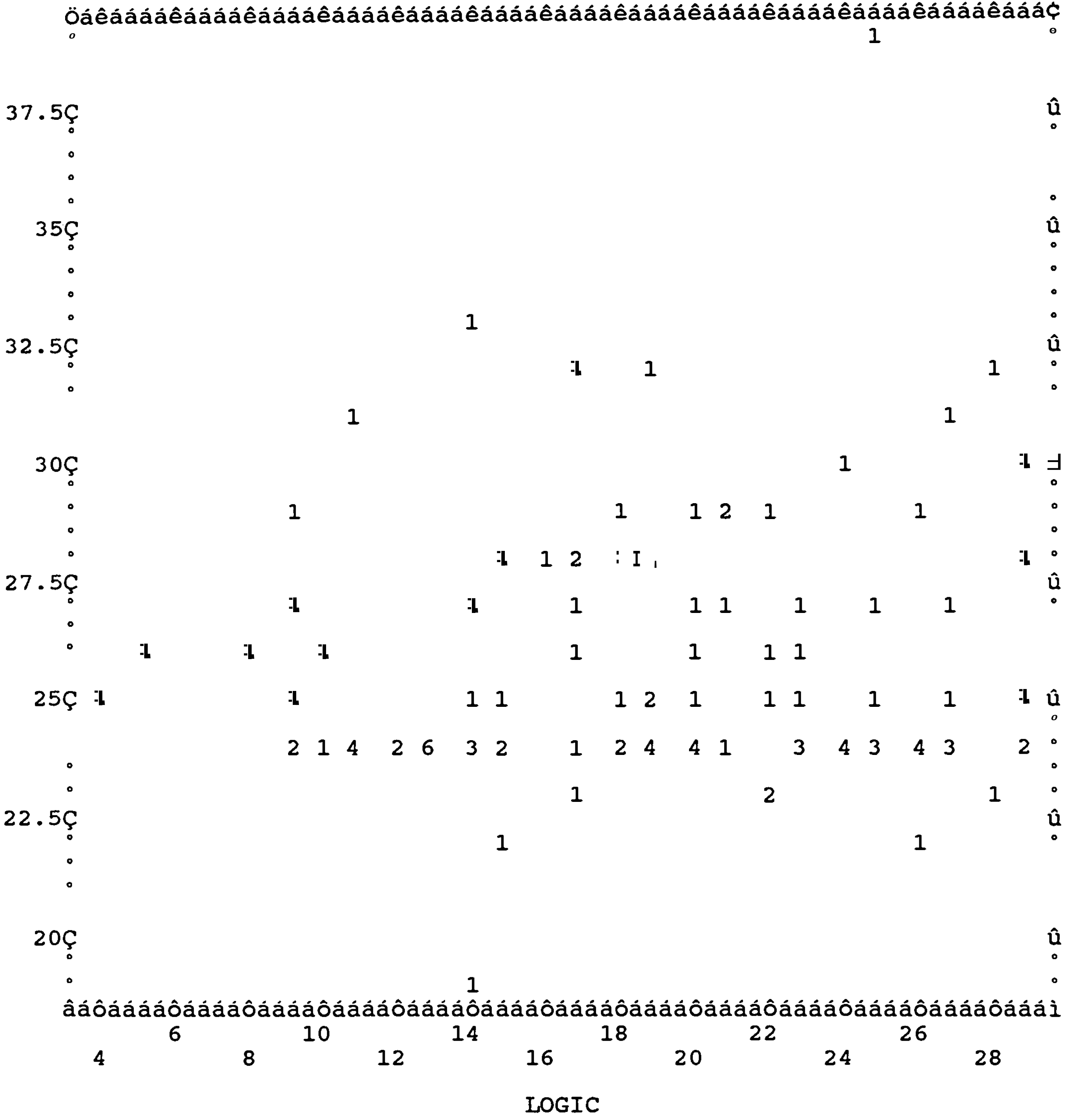
PLOT OF SUMFO WITH LOGIC



9 cases plotted.

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                              PLOT 09 SUMFO WITH DICHOTIC
          ÖêááááêááááêááááêááááêááááêááááêááááêááááêááááêááááêááááêááááêááááÇ
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               15        45        75       105       135       165
           0        30        60        90       120       150       180

                                       DICHOTIC

09 cases plotted.
```

Appendix E. Test of Train Handling Procedures

A Test of Train Handling Procedures for Freight Locomotive Engineers

Test Prepared and Copyrighted by Lyn R. Haber and Ralph Norman Haber
Human Factors Consultants, Highland Park, Illinois 60035
August 10, 1991

Instructions to the Testee

The following are 100 multiple choice questions pertaining to train handling procedures of over-the-road through freight trains. Each question has four alternative answers. Select the best alternative and mark it on the attached answer form. The questions are written so that one of the alternatives is the best answer for the given train, territory, and track configuration specified. A few of the questions may have to be interpreted in terms of the operating stategies used by the particular railroad.

<u>Train Configuration</u>: Unless otherwise stated, all the questions in the test refer to the handling of a freight train of about 100 mixed freight cars, a total weight about 6,000 tons, and a matched locomotive consist of 4 locomotives generating 2,500 hp each. Only a few of the cars are empty, and these are distributed evenly throughout the train. None of the cars are over-long or over-high. The automatic brakes are pressure-maintaining. The locomotives were made in 1976 or more recently, and are equipped with dynamic brakes. The automatic brakes use 26L equipment. There is no brake flow indicator, and no rear end telemetry device.

<u>Territory</u>: Nearly all questions will pertain to a particular kind of territory, which is specified in the question itself. If no territory is mentioned, then the question pertains to all territories.

The territories specified in the questions include five uniformly changing grades, and four non-uniform grades.

The uniform grades are:

1. <u>Level terrain</u>: no changes in grade greater than 1/4% (1/4 foot per 100 feet of track, or 12 feet per mile). Normally no in-train forces are generated by the terrain when it is level.
2. <u>Light ascending</u>: the grade increases at a rate between 1/4% to 1% (12 feet to 50 feet per mile)
3. <u>Heavy ascending</u>: the grade increases at a rate greater than 1% (50 feet per mile).
4. <u>Light descending</u>: the grade decreases at a rate between 1/4% and 1%
5. <u>Heavy descending</u>: the grade decreases at a rate greater than 1%.

The non-uniform grades include crests, hogbacks, sags, and undulating terrain. All are sufficiently steep to affect train handling procedures as the train negotiates the territory.

6. <u>Crest</u>: the grade has a long single rise followed by a long single descent, both at a rate exceeding the surrounding terrain by at least 1/4%. The distance from the beginning of the rise to the end of the descent is at least double the train length.
7. <u>Hogback</u> (also called a hump or knoll): the grade has a single short rise followed by a single descent. The prevailing terrain before and after the hogback may be level, generally ascending, or generally descending.
8. <u>Sag</u> (also called dip): the grade has a single descent followed by level, generally ascending, or generally descending terrain.
9. <u>Undulating</u>: a grade changing so often that an average train has some cars on three or more alternating ascending and descending grades.

<u>Curve Configurations</u>: Unless specifically mentioned, all track is assumed to be straight, without any curves greater than a half degree.

1. Dynamic braking

a. produces a **braking effort** similar to an independent brake, especially at low speeds

b. is generally less effective than the independent brake beause it is operative only on powered wheels

c. is more efficient than the independent brake because it does not depend on air pressure for its operation

d. produces a retarding force proportional to the load shown on the ammeter

2. Running releases made at low speed are dangerous because

a. some brakes may stick

b. the next brake pipe reduction may not apply properly

c. the train may make an unintended stop

d. excessive draft forces are likely due to insufficient time for **rearend** release

3. On level terrain with straight track, when crossing an intersecting track,

a. the speed of the consist should be reduced to 45 mph or track speed (whichever is less) until the consist has crossed

b. a high throttle should be momentarily reduced until the locomotive consist has crossed

c. the speed of the entire train should be reduced to 45 mph or track speed (whichever is less) until the entire train has crossed

d. no adjustment is needed unless required by special instructions

4. You are starting a train on level terrain. What do you do first?

a. advance the throttle to run 1

b. release all brakes

c. release only the automatic brakes

d. release only the independent brakes

5. A split reduction

a. occurs when a high initial brake reduction is followed by a much smaller reduction

b. increases the time it takes to stop the train

c. reduces excessive slack action

d. occurs whenever any combination of two or more of the braking systems are engaged at the same time.

6. Accelerating on level can produce undesirably high in-train forces if

a. the train stays below the minimum continuous speed too long

b. the throttle is advanced from notch to notch before the ammeter stablizes

c. the short-time rating is exceeded for at least five seconds

d. all of the above

7. Normally, slowdowns or stops should be completed with no more than a 15 psi total brake pipe reduction

a. to avoid split reductions
b. to avoid excessive run-in
c. because a full service reduction leaves no reserve braking power (except emergency brake)
d. to avoid sticking brakes after a subsequent release

8. When starting a train on undulating terrain with the **headend** on a descending grade, the engineer should follow the same procedures as when starting on

a. a heavy descending grade
b. a sag with the **headend** on the descending portion
c. a crest with the **headend** over the crest
d. none of the above: starting on undulating terrain is unique

9. Stretch braking

a. is only a good practice on level terrain
b. is used in slowing or maintaining speed to control slack in the train
c. requires that throttle reduction begins before brake application
d. can only be done when dynamic braking is available

10. The proper procedure to start on level terrain is

a. release independent brakes, advance throttle to run 1, and then release automatic brakes, and continue until **rearend** moves
b. release all brakes, advance throttle to run 1 to get locomotive consist moving, remain in run 1 (or 2 if necessary) until **rearend** moves
c. release all brakes, advance throttle several notches, but keep ammeter below 500 amps, until **rearend** moves
d. advance throttle gradually, but ammeter should not exceed 800 amps until speed reaches 5 mph

11. To slow in undulating territory,

a. the dynamic brakes are preferred to the automatic brakes
b. running releases of the automatic brakes, even at high speed, should be done with extra care, if at all
c. if automatic brakes are used, they may be supplemented with the independent brakes
d. if automatic brakes are used, the initial reduction should be at least 10 psi

12. You are starting a slack-stretched train on a light ascending grade. What do you do first?

a. advance the throttle slowly to run 3 or 4
b. release the automatic brake
c. advance the throttle to run 2
d. release the independent brake

13. You are negotiating level terrain at track speed with your throttle in notch 5. You know there is a slow speed zone ahead. You decide to slow your train keeping slack stretched. What should you do first?

a. Gradually reduce the throttle to idle
b. Gradually reduce the throttle to 1
c. Make a minimum brake pipe reduction
d. Make at least a 10 psi brake pipe reduction

14. To start a backup movement on level terrain:

a. allow sufficient time for the automatic brakes to fully release, then apply throttle
b. release the automatic brakes and immediately apply the throttle
c. release the independent brake, leave the automatic brakes applied, and throttle up until the locomotive consist moves at 1 mph
d. release the automatic brakes fully, throttle up gradually using the independent brakes to limit the locomotive consist speed to 1 mph

15. To control speed on a curved descending grade, where the curvature exceeds 2°, the engineer should

a. depend more on the automatic brakes than on the dynamic brakes
b. depend more on the dynamic brakes than on the automatic brakes.
c. depend on the same combination of braking that he would use on straight descending track
d. avoid the use of the independent brake, if at all possible

16. When accelerating after slowing through a sag

a. a light application of the automatic brakes until the locomotive consist starts uphill will help control slack
b. a steady advance of the throttle throughout the sag is proper as long as the ammeter stays below 800 amps
c. it may be necessary to reduce the throttle after the **rearend** of the train passes the sag to permit slack to adjust
d. it is best to hold the throttle constant until the **rearend** of the train clears the sag, then advance the throttle

17. You wish to slow while approaching a hogback. Your throttle is in notch 3 and you do not have dynamic brakes. What should you do first?

a. Immediately reduce the throttle one notch
b. Immediately make a minimum brake pipe reduction
c. Reduce the throttle one notch when the **headend** reaches the summit of the hogback
d. Make a minimum brake pipe reduction when the **headend** reaches the summit of the hogback

18. You are negotiating a sag travelling below track speed. What is the best train handling method to prevent run-in?

a. Travel through, making no changes in throttle or brakes.
b. Manipulate the throttle
c. Manipulate the throttle and automatic brakes
d. Manipulate the automatic brakes

19. The dynamic and independent brakes should not be used at the same time except when

a. changing from dynamic to air braking during stopping
b. starting a train on a crest
c. sand is not available or is impractical
d. all of the above

20. To stop on a heavy descending grade,

a. dynamic brakes should be used if available
b. automatic brakes should be used, even if dynamic brakes are available
c. the engineer is free to choose whatever brakes he prefers, depending on train makeup and terrain
d. the independent brake can be used to supplement dynamic braking until the dynamic brakes begin to lose their effectiveness

21. With doubleheading, extreme care in both road and helper consists must be used in the manipulation of the throttle to avoid

a. exceeding safe coupler limits and high L/V ratios
b. excessively high lateral forces due to coupler or car-body angularity
c. excessively high buff in-train forces, especially on curves, crossovers, and turnouts
d. all of the above

22. You wish to slow on an upcoming light descending grade. You wish to bunch your train. You do not have dynamic brakes. What do you do first?

a. Make a minimum brake pipe reduction
b. Make a brake pipe reduction of at least 10 psi
c. Gradually reduce the throttle
d. Make a minimum reduction and apply the independent brake

23. You are about to negotiate a hogback traveling at track speed. What is the best train handling procedure to minimize slack action and in-train forces?

a. Travel through, making no changes in throttle or brakes
b. Manipulate the throttle setting
c. Manipulate the throttle and automatic brakes on descent
d. Manipulate the automatic brakes

24. You are starting a stretched train on a light descending grade. What is the correct starting procedure?

a. release all brakes, allow the automatic brakes to release fully, and then advance the throttle to run 1

b. release the automatic brake fully. Then advance the throttle to run 1. Use the independent brake to control the speed of the locomotive consist.

c. release the independent brake, place throttle in run 1, and release the automatic brake

d. release the automatic brake fully. Then release the independent brake. Advance the throttle only after the entire train is moving

25. You are gradually approaching track speed over light descending terrain. What is the single best procedure to maintain correct speed?

a. Use the dynamic brake to control train speed

b. Apply the locomotive brakes

c. Make a minimum automatic brake reduction

d. Reduce the throttle setting one notch at a time

26. To start a fully stretched train stopped on a crest, where the middle of the train is on the summit, the first step is to

a. run out all slack

b. advance the throttle to 1 before releasing the independent brake

c. release the independent brake before releasing the automatic brakes

d. release the automatic brakes fully before releasing the independent brakes and adding power

27. To stop on a heavy descending grade, when the train has an uneven distribution of heavy and empty cars

a. if the heavy cars are at the **headend**, the independent brakes should be applied before the final stop

b. if the heavy cars are at the **headend**, keep some power applied until the final stop

c. if the heavy cars are at the **tailend**, the independent brakes should be applied before the final stop

d. use the same procedure as with a balanced weight train, but allow more distance to slow and stop

28. With a mid-train helper, extreme care in both road and helper consists must be used in the manipulation of the throttle to avoid

a. exceeding safe coupler limits and high L/V ratios

b. excessively high lateral forces due to coupler or car-body angularity

c. excessively high buff forces, especially on curves, crossovers, and turnouts

d. high **headend** tractive forces

29. You want to slow your train on a heavy descending grade, and you are certain that dynamic braking alone will not be sufficient. What should you do to slow your train?

a. Start with at least a 10 psi brake pipe reduction and supplement with the dynamic brakes

b. Start with a minimum brake pipe reduction, supplement with the dynamic brakes, and add further automatic brake reductions as needed.

c. Start with a minimum brake pipe reduction and allow the locomotive brakes to set as well, adding further automatic reductions as needed.

d. Supplement the dynamic brakes with a single service reduction

30. You are about to negotiate a crest. Which of the following is the best train handling procedure?

a. Manipulate the throttle and automatic brakes

b. Manipulate the dynamic and automatic brakes

c. Manipulate the automatic and independent brakes

d. Manipulate the throttle

31. You are starting a slack-bunched train on a light ascending grade. What is the correct starting procedure?

a. release the automatic brakes, immediately advance the throttle one notch at a time until the locomotive consist moves, then release the independent brakes

b. release the automatic brakes, release the independent brakes, then advance the throttle one notch at a time until the cars begin moving one at a time while brakes are releasing

c. release the automatic brakes, wait until fully released. Then add throttle sufficient to hold train and release the independent brake

d. release the independent brake and add sufficient throttle to hold the locomotive consist. Then release the automatic brake and gradually add further power to move one car at a time

32. You are approaching track speed on a heavy descending grade, Your train does not have dynamic brakes. Your throttle is in notch 3. How should you avoid overspeed?

a. Make a minimum brake pipe reduction. Immediately begin to throttle down one notch at a time

b. Make a minimum brake pipe reduction. When effective throughout the train, begin to throttle down one notch at a time

c. Make a minimum brake pipe reduction. When effective throughout the train, begin to throttle down and also apply the independent brake

d. Reduce the throttle one notch at a time. Then make a minimum brake pipe reduction

33. When planning to stop on level terrain

a. it is nearly always desirable to stop with slack stretched

b. the major consideration of how the slack is treated is the way in which the train is to be subsequently started

c. whether slack is to be bunched or stretched in stopping depends primarily on the distribution of heavy and light cars

d. the engineer can freely choose whatever method of stopping he wants, as long as he does it properly

34. When stopping while the train is crossing a sag or dip

a. it is usually preferred to keep slack bunched regardless of the overall average grade

b. it is usually important to keep slack stretched, regardless of the overall average grade

c. if the overall average grade is ascending, throttle reduction alone can often be used to stop the train

d. if the overall average grade is descending, slack should be kept stretched when using dynamic brakes

35. When braking against power, so as to keep slack stretched

a. do not let the independent brake apply

b. the independent brake should be applied along with the automatic brakes

c. the dynamic brake, when available, should be used along with the automatic brakes

d. the dynamic brakes, when available, are preferable to use rather than the independent brake

36. If power is applied too soon after making a running release, the train may separate. This is more likely if

a. the reduction being released was light (7 psi or less) and the train is stretched

b. the reduction being released was 10 psi or greater and the train is stretched

c. the reduction being released was 10 psi or greater and the train is long

d. the reduction being released was light, and the train is short

37. Stopping on an undulating terrain is best done with

a. automatic brake and throttle manipulation, even if the dynamic brakes are available

b. the dynamic brake, plus the independent brake as the train slows

c. throttle manipulation only, unless the train entered the undulating territory at high speed, and the stop was unexpected

d. the dynamic brakes, plus the automatic brakes as the train slows

38. When stopping on a light ascending grade,

a. if the stop can be made entirely with throttle reduction, this is usually preferable to the use of automatic or dynamic brakes

b. whatever method is used, the independent brake should be applied about 50 feet before the final desired stopping point

c. whatever method is used, the throttle should be at idle at least 50 feet before the desired stopping point

d. whatever method is used, avoid sand if possible

39. You are traveling just below track speed, with the **headend** just on the summit of the crest and the **rearend** still on the uphill side. In order to negotiate the crest properly, what should you do?

a. Make a minimum brake pipe reduction

b. Apply the dynamic brake

c. Gradually reduce the throttle

d. Do nothing until the locomotive consist is well over the crest

40. You wish to slow on a light ascending grade. What is the best method?

a. make a total brake pipe reduction of at least 10 psi

b. Make a minimum service reduction and apply the independent brake

c. Keep the same throttle setting and the let the terrain slow the train

d. Gradually reduce the throttle

41. You are starting a slack-bunched train on a light descending grade. What is the correct starting procedure?

a. release the independent brake, then advance the throttle to run 1 and release the automatic brakes

b. release the independent and the automatic brakes, then advance the throttle to run 1

c. release the automatic brakes, then release the independent brakes gradually, using the independent brakes to control **frontend** speed until the entire train is moving

d. release the independent brake gradually, release the automatic brakes and allow the entire train to stretch as the automatic brakes release

42. When accelerating after starting a train in a sag, once the entire train is moving

a. and the locomotive consist is still heading downhill, the independent brake can be used to control in-train forces

b. and the locomotive consist is heading uphill, hold the throttle in the lowest notch capable of maintaining movement until the **tailend** of the train clears the sag

c. regardless of where the locomotive consist is located on the sag, the throttle has to be advanced more slowly then when accelerating on level, so that the slack can adjust through the sag

d. regardless of where the locomotive consist is located, this task is similar to accelerating on level

43. When negotiating a heavy descending grade with dynamic brakes, the best train handling procedure is to

a. use the dynamic brakes alone, or supplement them with the independent brakes, if necessary

b. start with the automatic brakes and supplement them with the dynamic brakes, if necessary

c. set retainers before entering the grade

d. use the dynamics brakes alone, or supplement them with a minimum automatic brake reduction, if necessary

44. You want to start your train on a hogback. The locomotive consist and the first third of the train are on the descending part of the hogback. The first step is

a. advance the throttle to 1 until the entire train is in motion and then advance the throttle notch by notch

b. release the automatic brakes to let the slack run out, and then add throttle slowly

c. gradually release the independent brake and add throttle to keep the locomotive speed slow until the entire train is moving

d. any of the above, depending on the conditions.

45. You are negotiating level terrain at track speed. Ahead is a sag. What should you do?

a. Make no change in the throttle or brake

b. Reduce speed

c. Keep the train speed constant

d. Add throttle gradually

46. When stopping on a heavy ascending grade, the train should be

a. stretched

b. bunched

c. either stretched or bunched, depending on train makeup and territory

d. stretched only when dynamic braking is available

47. When negotiating a heavy descending grade without dynamic brakes, the best train handling procedure to control speed is to

a. hold throttle as constant as possible and make several automatic brake applications

b. use primarily throttle manipulation and minimum automatic brake application

c. supplement throttle manipulation with independent brake applications

d. set retainers before entering the grade

48. Remote locomotive units are particularly useful in cold temperatures because they reduce

a. brake pipe gradient
b. brake pipe charging time
c. brake release time
d. all of the above

49. To slow a train on a heavy descending grade, cycle braking of the automatic brakes is acceptable

a. if dynamic brakes are not available
b. if speed is reduced sufficiently before the brakes are released to provide adequate time to recharge before the next cycle
c. if when speed drops below 10 mph the engineer is prepared to stop the train rather than release the brakes
d. only if all of the above conditions are met

50. The time required for the automatic brakes to achieve release on the last car depends on

a. train length
b. brake pipe leakage
c. the amount of reduction
d. all of the above

51. If one or more locomotives in the consist starts to lurch or slip during a start, what is the safest procedure?

a. add another notch of power
b. add sand
c. close throttle, come to stop, and determine the cause
d. close throttle, take slack, and start over again

52. To stop on a heavy descending grade with dynamic brakes available

a. the dynamic brakes should be fully applied by the time the first application of the automatic brakes becomes effective
b. automatic brake applications should precede the dynamic brakes
c. the independent brake should be used to supplement the automatic brake if needed
d. avoid using sand if possible

53. You are negotiating undulating territory in which the prevailing grade is ascending. Your speed is 10 mph below track speed. What is the best train handling method to maintain speed?

a. Travel through, make no changes in the throttle or brakes
b. Manipulate the throttle
c. Manipulate the throttle and automatic brakes
d. Manipulate the automatic brakes

54. You wish to slow on a heavy ascending grade. What is the best method?

a. Make a minimum brake pipe reduction

b. Keep a high throttle setting and allow the terrain to slow the train

c. Make a minimum brake pipe reduction and apply the independent brake

d. Gradually reduce the throttle

55. You are beginning to accelerate on light descending terrain with a fully bunched train without dynamic brakes. When the entire train is moving you should

a. fully release the independent brake before adding any throttle until the train is fully stretched

b. advance the throttle at least to run 1 before fully releasing the independent brake

c. gradually release the independent brake while slowly adding throttle to stretch the train

d. continue to work the independent brake to keep the train bunched as long as possible as it gains speed

56. Your train is accelerating rapidly and approaching track speed over level terrain. What should you do to achieve correct speed?

a. Maintain your present throttle setting until you reach track speed, and then notch back quickly to a setting that should provide a balance speed

b. Start notching back now gradually

c. Maintain your present throttle setting until your speed is slightly in excess of track speed, and then notch back quickly to a setting that should provide a balance speed

d. Maintain your present throttle setting until you reach track speed, and then notch back gradually to a setting that maintains balance speed

57. You are starting a slack-stretched train on a heavy ascending grade. What is the correct procedure?

a. release the automatic and independent brakes, then advance the throttle slowly to a position sufficient to hold the train

b. sand, then release the automatic brakes and advance the throttle slowly to a position to hold train

c. advance the throttle to notch 1, then release the automatic and independent brakes

d. release the automatic brakes, advance the throttle slowly, sufficiently to hold the train, then release the independent brakes

58. When beginning to accelerate a fully bunched train on a light descending grade, and dynamic brakes are being used

a. the independent brake is used to keep slack bunched until desired speed on descent is achieved, or bottom is reached

b. The independent brake is gradually released as the dynamic brakes become effective

c. Both dynamic and independent brakes must be released by at least 10 mph so the train can be stretched

d. Throttle is added before dynamic brakes become effective to reduce in-train forces

59. You are negotiating undulating terrain. The best train handling goal is to

a. keep at track speed
b. vary speed with the ups and downs of the terrain
c. keep the locomotive consist speed constant
d. avoid heavy braking

60. To plan a start on a hogback, the engineer should consider

a. where the train is located in relation to the summit of the hogback
b. the slack condition of the train when it stopped
c. the severity of the curvature of the track over the hogback
d. all of the above

61. When accelerating on level terrain, pausing between each throttle advance insures that

a. in-train forces do not become excessive
b. wheel slips do not occur
c. excessive amperage is avoided
d. all of the above

62. Retainers are used on heavy descending grades when

a. dynamic brakes alone would not be sufficient to control train speed
b. automatic and dynamic brakes together would not be sufficient to control train speed
c. the grade exceeds 3%
d. the total train weight exceeds 10,000 tons

63. Which of the following describe the impact of curves on train handling?

a. Curves increase rolling resistence and therefore produce faster slowing and greater buff forces than do straight track
b. Curves increase lateral forces and therefore produce a greater chance of rail turnover and wheel climb
c. Curves increase draft forces when starting and make string-lining more likely
d. All of the above

64. With large locomotive consists, there is the potential for too much dynamic braking capacity. Dynamic braking capacity must be limited when

a. the independent brakes are also used
b. crossing turnouts and in sharp curves
c. there are high, long, or unloaded cars near the frontend of the train
d. all of the above

65. On a heavy descending grade, using primarily the dynamic brake to retard the train, if the dynamic brakes suddenly become ineffective, the engineer should

a. stop the train quickly with an emergency application
b. immediately add independent brake to replace the dynamic
c. reduce throttle immediately to idle if not already there
d. make a full service reduction, allowing the independent brake to set

66. Once the entire train is moving, accelerating on curved heavy ascending terrain

a. can be done at the same rate of notching up the throttle as on straight track, as long as the curve is 2° or less.
b. requires a slower rate of notching up to prevent string lining of heavy cars
c. requires a slower rate of notching up to prevent separation
d. is safer if the train has a higher hp/ton ratio

67. When starting a train in a sag when the locomotive consist is in the ascending portion, you should

a. release the automatic brakes and the independent brake to bunch the train before applying power
b. release the automatic brakes and apply minimum power as the independent brake is released to prevent the headend from rolling back
c. advance the throttle gradually several notches to stretch the train before releasing the automatic brakes
d. keep the automatic brakes applied until after the independent brakes are released to prevent high in-train forces

68. Train separation is likely when starting on a crest

a. at the headend on the descending side of the crest, just behind the locomotive consist, where drawbar forces are maximum
b. at the headend, especially when the crest is also on a curve
c. at the middle of the train at the summit, where drawbar forces are maximum
d. none of these: train separation is not a serious problem on crests

69. You are traveling at track speed. You are about to enter undulating terrain. What should you do?

a. It depends on the prevailing grade of the undulations
b. Make no change in throttle or brakes
c. Keep the train speed constant
d. Reduce speed

70. 'You have been traveling over level terrain. Ahead is a cresting grade, and you plan to slow while negotiating through the cresting territory. What is the best method?

a. Gradually reduce the throttle while the locomotive consist is on ascending portion of the grade up the crest

b. Gradually reduce the throttle as soon as the locomotive consist comes over the crest

c. Make a minimum reduction as soon as the locomotive consist comes over the crest

d. Make no change, allowing the ascending portion of the crest to slow the train

71. Which single factor has the biggest influence on stopping distance for a freight train?

a. Speed
b. Train weight
c. Train length
d. Weather conditions

72. To stop a train on a cresting grade

a. begin throttle reduction while the locomotive consist is cresting the grade

b. do not use automatic brakes when dynamic brakes are available, to prevent high draft forces at the rear of the train

c. the highest draft forces will occur just behind the locomotive consist after the consist clears the crest

d. the independent brakes should be set about 50 feet before reaching the final desired stopping point

73. To stop on a light descending grade with slack bunched, the first step is to

a. make a throttle reduction
b. make a light application of the automatic brakes
c. make a heavy application of the automatic brakes
d. the engineer can freely choose to start with throttle manipulation or with a brake application

74. The time needed for the automatic brakes to begin to apply after an application is initiated by the engineer is

a. the same for a 6 psi as for a 12 psi reduction
b. greater for a 6 psi than for a 12 psi reduction
c. less for a 6 psi than for a 12 psi reduction
d. whether it is the same, greater or less depends on the brake pipe pressure before the reduction

75. When stopping on a hogback

a. a slack-stretched method of stopping should be used to avoid large buff in-train forces

b. if the locomotive consist is on the ascending portion of the hogback, increase the throttle while the automatic brakes apply

c. if the locomotive consist has cleared the summit of the hogback, advance the throttle sufficiently to maintain speed as the brakes apply.

d. all of the above

76. Sanding on curves

a. is less effective in increasing adhesion than on straight track

b. should be minimized because it increases lateral forces

c. is needed more than on straight track due to the centrifugal forces generated by the train

d. has the same impact on train handling as on straight track

77. To stop a train on level terrain and keep the slack stretched, you should

a. apply the automatic brakes before you make any throttle reduction

b. reduce the throttle to idle before you begin any brake application

c. use the independent brake to control in-train forces

d. allow the independent brakes to set when applying the automatic brakes

78. Accelerating through undulating territory should be done

a. with power added every time the locomotive consist starts down to maintain a stretched condition

b. more quickly than over uniform terrain to keep slack stretched at all times.

c. not at all: speed should be held as constant as possible until the undulations end

d. at a slow rate

79. You are starting a slack-stretched heavy train with 3 hp/ton on a 2% ascending grade. If the locomotive consist does not begin to move forward as the independent brakes are released and power is added, you should:

a. keep adding more power, at least until the ammeter goes above 1200

b. add sand

c. consider doubling the hill

d. allow the locomotive consist to roll back a few feet to pick up some slack and then try again

80. You are starting a slack-bunched train on a heavy descending grade. The initial control of the speed of the locomotive consist is made by:

a. throttle manipulation

b. releasing the automatic brakes

c. gradual release of the independent brakes

d. gravity

81. lo accelerate after starting on a hogback

a. the independent brake should be used to control speed to prevent excess stretching

b. high throttle position should be used as soon as the locomotive consist crosses the hogback to prevent run-in

c. the throttle should be advanced carefully, using the ammeter to indicate when severe in-train forces are likely on the hogback

d. all of the above

82. If you have to initiate a slowdown just as the headend reaches the bottom of a sag, your first action should be to make:

a. a minimum reduction of the automatic brakes

b. a more rapid than usual reduction in throttle

c. a minimum reduction of the automatic brakes, allowing the independent brakes to set as well

d. a normal reduction of the throttle before setting any brakes

83. You wish to slow on a light descending grade, keeping your train stretched. Your throttle is in notch 3. You do not have dynamic brakes. What do you do first?

a. Reduce the throttle gradually

b. Make a minimum brake pipe reduction

c. Make a brake pipe reduction of at least 10 psi

d. Make a minimum brake pipe reduction and apply the independent brake

84. When stopping on light ascending grades,

a. it is advantageous to have slack stretched for the next start

b. it is advantageous to have slack bunched because there is less run-in forces during the stop

c. it is advantageous to have slack bunched to reduce rollout during starting

d. Either slack stretched or bunched is acceptable, depending on train makeup

85. When stopping a train on a 2° curve, and dynamic braking has been used to slow the train

a. an automatic brake application should be made to supplement the dynamic brake

b. an automatic brake application should be made and a corresponding reduction in dynamic braking be made

c. the dynamic brakes should be completely released and replaced by the independent brakes

d. the dynamic brakes should be completely released and replaced by the automatic brakes

86. When it is desirable to take slack in a train stopped on an ascending grade, in order to start'the train (and no communication with the rear of train is available), the engineer should

a. make a brake pipe reduction sufficient to just hold the train, reverse the train with low throttle until all the slack is bunched, release the brakes and advance the throttle only enough to move the train forward

b. release all brakes and allow the train to roll back until the locomotive consist has bunched into the cars, then advance the throttle to run 1 to move forward

c. release all brakes, reverse the locomotive and advance throttle to run 1 until the train is bunched. Then set all brakes, reverse again, advance the throttle and release the brakes.

d. all of these are proper

87. In planning to slow on a light ascending grade, when past experience suggests that throttle reduction alone will not be sufficient, you should

a. make a minimum brake pipe reduction and then begin to throttle back

b. reduce the throttle to idle before beginning a minimum brake pipe reduction

c. reduce the throttle gradually and supplement with the independent brake

d. begin to throttle down and supplement with a minimum brake pipe reduction

88. You are negotiating level terrain at track speed and decide to slow your train allowing slack to bunch. What should you do first?

a. Make a minimum brake pipe reduction

b. Apply the independent brake

c. Gradually reduce the throttle

d. Make at least a 10 psi brake pipe reduction

89. When accelerating a fully stretched train on heavy ascending terrain

a. to avoid the minimum continuous speed limit, the engineer should get to a high throttle position as soon as feasible

b. sanding should be used whenever wheel slip is anticipated

c. high in-train forces occur from too high a throttle position when still at low speed

d. all of the above

90. In hogback territory, when accelerating after a slow down

a. buff forces among the cars on the hogback is the greatest concern

b. control of slack action within the train at the point where it crosses the summit of the hogback is the greatest concern

c. control of slack must be handled by manipulation of the throttle along with the independent brake

d. the rate of acceleration can be increased once the locomotive consist begins descent off the hogback

91. You are starting a slack-bunched train on a heavy descending grade. The independent brake had been fully applied to hold the train. What should you do first?

a. apply the automatic brake
b. release the independent brake
c. advance the throttle to run 1
d. ascertain that the automatic brake system is fully recharged

92. You have started your train and stretched it. In order to accelerate properly, you should:

a. advance the throttle one notch at a time, pausing a minimum of 20 seconds before making the next advance

b. advance the throttle one notch at a time, pausing until the speedometer registers at least a 2 mph gain

c. advance the throttle as many notches as you can until the ammeter exceeds 800 amps on any advance.

d. advance the throttle one notch at a time, watching for the ammeter to stabilize or drop before the next advance

93. You wish to slow while crossing over a cresting grade. What do you do first?

a. Gradually reduce the throttle
b. Make a minimum brake pipe reduction
c. Make a total brake pipe reduction of at least 10 psi
d. No change--allow the ascending grade to slow the train

94. To stop a train on level terrain with slack bunched, what is the first step?

a. Reduce the throttle gradually to idle to gather the slack
b. Apply light independent braking to gather the slack
c. Make a light automatic brake application while beginning to reduce the throttle
d. It depends upon the makeup of the train

95. In general, when stopping on a light descending grade, the engineer

a. should usually stop with slack bunched, as it makes it easier to start again

b. should usually stop with slack stretched, as this reduces the in-train forces during the stop

c. should usually stop with slack stretched if dynamic brakes are available, otherwise bunched.

d. is free to bunch or stretch the slack as dictated by train makeup and territory

ANSWER KEY

1. d
2. d
3. b
4. b
5. c
6. b
7. ε
8. b
9. b
10. b
11. b
12. b
13. ε
14. a
15. a
16. ε
17. d
18. b
19. a
20. b
21. a
22. c
23. b
24. c
25. d
26. d
27. a
28. ε
29. b
30. d
31. b
32. b
33. c
34. ε
35. a
36. a
37. a
38. a
39. ε
40. d
41. c
42. ε
43. d
44. c
45. b
46. a
47. b
48. d
49. d
50. d
51. c
52. a
53. b
54. d
55. ε
56. b
57. d
58. b
59. c
60. d
61. d
62. b
63. d
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68. c
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78. d
79. c
80. c
81. c
82. a
83. b
84. a
85. b
86. a
87. d
88. c
89. c
90. b
91. d
92. d
93. a
94. a
95. d