PRELIMINARY COPY

RAILROAD ENGINEER REQUISITE KNOWLEDGE AND SKILLS

Preliminary Report

Prepared for:

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Massachusetts 02142

Prepared by:

Dunlap and Associates, Inc.
One Parkland Drive
Darien, Connecticut 06820

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Contract No. DOT-TSC-732

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RAILROAD ENGINEER REQUISITE KNOWLEDGE AND SKILLS

I. INTRODUCTION

This is the first in a series of preliminary reports concerned with the identification of minimum knowledge and skill requirements for the safe performance of selected railroad jobs. This report is concerned with the railroad engineer and will be followed by a report on the train dispatcher and a report on the conductor, front and rear end brakemen.

Preliminary reports of job knowledge and skill requirements will be critically reviewed by all cognizant individuals. Thus, the format and content of draft requirements are subject to change before appearing in the final technical report for this project in February, 1975.

II. ASSUMPTIONS AND REQUIREMENTS

At the outset of the contract, it was stipulated that the analytical efforts should be primarily concerned with over-the-road freight operations, as opposed to passenger operations and yard operations. Although there is a great deal of commonality among all these operations, it was felt that over-the-road freight operations, on the whole, were the most demanding of the engineer in terms of knowledge and skill requirements. Diesel/electric locomotion was another given, to the exclusion of all other forms of existing locomotion.

In developing the inventory of knowledge and skills, several other guidelines were stated.

First, the requirements developed should be minimum, safety-related requirements, amenable to evaluation and regulation by the Federal Railroad Administration under provisions of the Federal Railroad Safety Act of 1970. The scope and detail of the analysis should, therefore, be sufficient to determine that personnel in safety-critical railroad jobs "possess that minimum of knowledge and skills required to assure safe performance of their jobs." *

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* Contract No. DOT-TSC-735, p. 2

In support of the foregoing objectives, it was also necessary to bear in mind that the knowledge and skills identified be measurable. Knowledge requirements must be so stated as to define behavior which is measurable by oral and/or written examinations. Skill requirements must be expressed so as to specify behavior which may be observed and evaluated in the real world or simulator environments.

Finally, the contract stated that the "derivation of the products... shall be guided by, but not necessarily constrained by, the formats and techniques specified for air crew members in the Federal Aviation Regulations." *

III. METHOD

Extensive technical documents on all aspects of railroading were amassed with the kind assistance of the contract technical monitor. Most of these documents appear in the reference section of this document. An intensive review of these documents was conducted with the aim of identifying major railroad engineer activities and requisite knowledge in support of these activities. Analytical worksheets were prepared to organize the development of the information base. An example of such a worksheet appears on the next page. For each major function which an engineer may perform, the activities or tasks in support of that function were listed in the ACTIVITY column. For each activity entry, the necessary supporting elements of knowledge were listed in the RELATED KNOWLEDGE column. The major functions identified in the Railroad Engineman's Task and Skill Study, prepared for the Federal Railroad Administration by the McDonnell Douglas Corporation, served as an initial basis for organizing and developing our analysis. In addition to the documentary resources, valuable information was gained by the project staff from a three hour ride in the cab of a freight train on a northeastern railroad. During the ride, extensive discussions were held with the road foreman and engineer regarding train handling and operating rules.

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* Contract No. DOT-TSC-736, p. 3.

ACTIVITY	RELATED KNOWLEDGE
1. Reduce speed appropriately, upon warning of a possible obstruction ahead	1.1 Radio telephone procedures, message formats 1.2 Content/format of train orders 1.3 Normal stopping/slowing procedures
2. Observe/recognize particular obstruction on tracks	2.1 Proper scanning procedures for track ahead 2.2 Types of obstructions which may be encountered
3. Determine need for and feasibility of stopping for obstruction; weigh threat to life and cargo on board as a result of colliding or attempting to stop vs. threat to above plus cargo or life associated with the obstruction if a collision is allowed	3.1 Locomotive capabilities, if any, of obstruction 3.2 Damage potential to train's crew or cargo from collision with obstruction; threat to life associated with obstruction from collision with train 3.3 Ability to stop, i.e.: 3.3.1 Train dynamics and condition, i.e.: . Present speed . Number of cars . Type of cars . Locations of heavy and light cars . Presence of special, fragile or dangerous cargo . Type and condition of brake system . Mass action of entire train 3.3.2 Contour of trackage (e.g., curves, grades) 3.3.3 Weather conditions 3.4 RR operating rules governing this situation
4. Take appropriate reaction to obstruction, which may include: . No action . Sounding of horn . Service application of brakes . Emergency application of brakes . Measures for personal and crew protection	4.1 Procedures (communication, control actions) for: . Service and emergency applications . Horn sounding 4.2 Location and function of relevant controls and displays 4.3 RR operating rules governing this situation

Drafts of requisite knowledge and skills were developed from the analytical worksheets and documents. A final draft of these requirements was reviewed by an operating engineer who serves as a staff consultant.

IV. REQUIRED KNOWLEDGE AND SKILLS

In reviewing sections A and B below, the reader is advised to bear several points in mind.

The organization of knowledge requirements does not necessarily denote the organization that would be optimum for a course of instruction. With the identified body of minimum knowledge as a given, the attempt was made to organize it into logical and topical groupings for the purpose of this presentation alone. Thus, if one were to develop a minimum course of instruction from the material embodied in Section A, good instructional logic and continuity might require a different organization and sequencing of material.

In arranging the body of minimum skills found in Section B, the foreseen method of skill measurement served as the organizational guideline. Namely, minimum skill requirements were ordered in the manner which they could be observed in a reasonable operational sequence during a "checkride" in the real world or a simulator.

Finally, it should be clearly understood that the entire body knowledge and skill requirements set forth here will not apply to all engineers on all railroads. Railroads differ in their modes of operation, such as terrain features of operating territories, equipment/hardware in service, train traffic control methods and signal systems, operating procedures and rules, etc. Therefore, in applying Section A and B to a specific railroad, an accounting will have to be made of which requirements are applicable to the railroad's modes of operation and which are not. Unapplicable requirements should be dropped from further consideration. Once the knowledge and skill requirements are calibrated to each specific situation, then they may be applied.

A. RAILROAD ENGINEER KNOWLEDGE

A railroad engineer must demonstrate a practical knowledge and understanding of at least those following subjects which are applicable to the railroad's modes of operation:

1. Railroad Organization

    a. Territorial layout and terrain features of the railroad's divisions and branches

    b. Duties of key operational personnel such as division engineer, master mechanic, trainmaster, road foreman, engineer, pilot, fireman, brakemen (front, rear), conductor, train dispatcher, tower operator and train order operator.

2. Equipment and Facilities

    a. Locomotives

        1) Locomotive types and capabilities (e.g. manufacturer, horsepower, range, equipment suites)

        2) Diesel/electric power equipment

            a) Function, location, interrelationships and requirements for safe operation and control of major components, i.e. engine, generators and traction motors

            b) Function and location of operating controls and indicators for the power system

            c) Operational concepts

                . Problems of engine overspeed, generator and traction motor overload

                . Tractive force as a function of number of powered axles

        3) Braking equipment

            a) Air brakes

- Common types of air brake systems available to include No. 6, 24 RL and 26 L

- For each system, the function, location, interrelationships and requirements for safe operation and control of:

  - Major components, i.e. compressor, reservoirs, valves, brake cylinders and shoes

  - Brake handle positions for the independent and automatic brakes for application and release

  - Pressure gauges for the reservoirs and brake pipes

- Operational concepts

  - Requirements for charging and maintaining air pressure

  - Effect of train length on brake application and release time, brake pipe gradient

  - Causes of penalty brake applications

  - Causes of unintentional brake releases

  - Conditions for which independent brakes are recommended and not recommended

  - Conditions for which automatic brakes are recommended and not recommended

b) Dynamic brakes

- Common types of dynamic brake systems available, to include taper, flat, extended range

- For each system, the function, location, interrelationships and requirements for safe operation and control of:

- Major components, i.e. generators, motors, cooling grids

- Brake handle positions and indicators

. Operational concepts

- Use of traction motors as generators

- Conditions under which dynamic brakes are available and useful

- Conditions under which dynamic brakes are not recommended

- Advantages and disadvantages of using dynamic brakes in conjunction with air brakes

- Interlock with air brakes

c) Handbrakes

. Location and operation of various types available

. Conditions for employment

4) Sanding equipment

a) Manual and automatic systems

b) For each system, the function, location, inter-relationships and requirements for safe operation and control of major components

c) Operational concepts

. Situations requiring automatic or manual sanding

. Benefits and precautions associated with sanding

5) Safety and communications equipment

a) Function, location, and operation of all such equipment, to include safety control pedal, electronic alertness control, automatic train stop/control, overspeed control, train radio, auditory signals (bell, horn), flares/fusees, torpedoes, and fire extinguishers.

b) Situations for deployment or continuous operation of this equipment

b. Cars

1) Types of common cars in service

2) Function, location, interrelationships and requirements for safe operation of:

a) Couplers and draft gears
b) Air brake components, i.e. reservoirs, valves, brake pipe and connectors, brake cylinders and shoes.
c) Handbrakes

3) Operational concepts

a) Performance characteristics loaded versus unloaded
b) Special requirements for handling certain cars or hazardous cargoes
c) Advantages and disadvantages of journal bearing types

c. Trackage and associated equipment

1) Types of common trackage, e.g. main, siding, single and multiple

2) Function of trackage associated equipment i.e. towers, humps, retarders, switches, derails, frogs, bunters, detectors and transmitters for overheated journals, train speed and automatic train stop/control sensors and transmitters

3) Advantages of welded vs. jointed rails

d. Signals

1) Design, location and operation of all fixed roadside visual signals and cab signals

2) Types of manual visual signals, e.g. hand, flag, lamp

3) Aspects and indications of all visual signals

4) Types and meanings of horn signals

e. Terminals, yards, enginehouse/turntable

1) Functions and locations of these facilities

2) Rules and requirements for safe operation within or near these facilities

3. Operations and Procedures

a. Mission preparation

1) Required information for mission, i.e. train orders, timetable and rules, special notices, official railroad time, load consist information

a) Need for verification of received information

b) Communications with yard personnel and crew in preparation for movement

c) Procedures for executing required reports

2) Procedures for performing inspections of power consist, i.e. exterior from ground, engine room(s), lead unit cab, trailing unit cab(s)

a) Satisfactory and unsatisfactory indications

b) Corrective actions and reports

b. Starting and initial movement

1) Initial conditions prior to starting engine

2) Procedures for starting engine

3) Post-start inspections

4) Procedures for forming power consist

a) Lead/trail setup and control configurations
b) Air brake application and leakage tests
c) Corrective actions and reports

5) Procedures for coupling power consist to load consist and verification of coupling.

a) Air brake application and leakage tests
b) Corrective actions and reports

6) Rules and procedures for moving trains through yard to main track

c. Over-the-road

1) Basic handling

a) Factors affecting use of power and braking:

- Train and track considerations affecting tractive and braking forces, i.e. friction (rolling resistance, wind resistance, rail adhesion, wheel/shoe resistance, track curvature), grade, speed, type and location of power consists, train length, train weight and weight distribution, track alignment.

- Environmental considerations, i.e. moisture, snow, and visibility restrictions

- Time and distance considerations, i.e. brake application and release time, required stopping distances for various grades, curves, and train lengths/weights.

- Development of lateral forces and their effect on wheel lift, rail spread and roll over, and possible derailment.

b) Slack control

- Slack development and location within train

- Procedures for controlling slack, i.e., bunching, stretching

- Effects of ineffective slack control, i.e., run-in, drawbar pull

2) Intermediate handling

a) Grade and curve territories

- Procedures for negotiating, stopping and restarting trains on:

  - Level territory with curves
  - Straight territory with light and heavy descending grade(s)
  - Straight territory with light and heavy ascending grade(s)
  - Light and heavy ascending and descending grades with curves
  - Cresting grades
  - Undulating grades
  - Sag or dip territory
  - Hump, knoll or hog back

- Procedures for controlling train by:

  - Cycle braking
  - Dynamic braking coupled with automatic braking
  - Throttle modulation
  - Handbrake and retainers, when required

- Precautions to be observed, e.g. wheel slip, wheel slide, rail burn, traction motor commutator stall burns, excessive draw bar forces, stringlining

- Unadvisable actions on grades and curves, e.g. stopping on cresting grade; speed changes within, near beginning or end of curve; excessive throttle or brakes on curves

b) Power assistance

- Remote control equipment

- Available modes of operation
- Advantages and precautions associated with remote control equipment
- Procedures for setting up and checking out configuration
- Procedures for combined power and braking operations

. Pusher and helper

- Procedures and precautions associated with pusher and helper operations

c) Braking assistance

. Procedures for setting up and checking out repeater relay system

. Procedures for operating in consort with repeater relay system

3) Special Handling

a) Procedures for:

. Restarting train after penalty brake application

. Operations in the event of loss of dynamic brakes on moderate to heavy downgrade

. Operations after emergency brake application

. Operations after unintential brake release

. Operations after break-in-two

. Operations after minor and major derailments

. Correcting and/or reporting operating difficulties, e.g., engine malfunction and shutdown, excessive air pressure leakage, overcharged brakes, broken brake pipe, sticking brakes, sanding malfunction/failure, traction motor malfunction/failure, overheated journal bearing(s)

4) Train traffic control

a) Standard time and the timetable

b) Classes of trains, i.e. regular, extra

c) Classes of train speeds, i.e. limited, medium, reduced, restricted, slow, yard

d) General rules for movement of trains over the road

e) Design and operation of major traffic control system(s) in use, e.g.

- Train order
- Block signals
  - Manual
  - Automatic
- Automatic cab signals
- Centralized traffic control
- Voice train control

f) Procedures for protecting a train which may be overtaken or intercepted by another train

5) Communications

a) Rules and procedures for operating train radio in following modes:

- To and from dispatcher
- To and from outside crew
- To and from caboose

b) Format and content of train orders

c) Rules and procedures for telephone communications

d) Requirements for completion of work order/ defect report

d. Mission completion

1) Rules and procedures for leaving main track and moving through yard to final destination

2) Requirements for securing (engine running) and shutting down and securing the power consist

3) Procedures for completion and filing of operational and maintenance reports with proper authorities

4. Safety

a) Engineer fitness

1) Physical and mental fitness requirements

2) Major sources of engineer performance decrements:

a) Distraction
b) Fatigue
c) Physical impairments

- Alcohol
- Drugs
- Injury
- Disease (e.g. epilepsy, diabetes, etc.)
- Sensory and/or motor impairment

b) Injury avoidance

1) Types and locations of potential hazards and injuries

a) Electrical
b) Thermal
c) Chemical
d) Acoustical
e) Physical force

- Being struck
- Falling
- Striking an object

2) Recommend protective clothing and equipment

3) Precautions for:

a) Moving on or about tracks
b) Getting on/off locomotives and cars
c) Operating the locomotive
d) Inspecting or maintaining locomotive
e) Operating handbrakes
f) Use of tools or appliances

5. Basic railroad terminology required for safe and efficient communication

B. RAILROAD ENGINEER SKILLS

A railroad engineer must demonstrate an ability to perform satisfactorily at least those following activities which are applicable to the railroad's modes of operation:

1. Mission Preparation

    a. Obtain required information for mission to include at least the following:

        1) train orders
        2) timetable and rules
        3) special notices
        4) calibration with official railroad time
        5) load consist information

    b. Perform the following types of locomotive inspections:

        1) exterior from ground
        2) engine room(s)
        3) lead unit cab
        4) trailing unit cab(s)

2. Starting and Initial Movement

    a. Start engine and perform checkout

    b. Form and checkout power consist

    c. Couple locomotives to load consist and verify coupling

    d. Charge air brake system as required and perform brake application and leakage tests

    e. Move train through yard to designated main track

3. Over-the Road Operations

    a. Basic handling

        1) Accelerate train and maintain designated speed

        2) Decelerate and maintain one-half designated speed

        3) Stop train employing each of the following braking systems/methods as appropriate:

a) service application(s) of automatic brake
b) independent brake
c) dynamic brake
d) automatic brake and dynamic brake
e) power braking

4) Bunch slack and resume movement

5) Enter and leave a siding

6) Drop-off and pick up cars

7) While enroute:

a) Comply with the indications of all road and cab signal aspects

b) Comply with and/or initiate all other visual or auditory signals, as necessary, on:

- The condition of own train
- The condition of passing trains
- Malfunctioning signals or roadside equipment
- Defective tracks, switches, etc.
- Other hazardous conditions

c) Control throttle so as to avoid stress on engine, generator and traction motors

d) Control throttle and brakes to avoid wheel slip and wheel slide

e) Control slack within train, avoiding excessive buff action and coupler/draft gear strain

f) Control automatic brake system so as to prevent:

- Failures or unintended releases while underway or stopped
- Sticking brakes

g) Respond to applications of automatic brakes from the caboose

h) Recognize and take appropriate actions sufficiently in advance of:

- Grade crossings
- Environmental hazards (natural, man made)
- Equipment and trains adjacent to track
- Message pick-up points
- Obstructions, debris
- Onset/offset of grades, grade crests, undulating territory
- Onset/offset of curves

b. Intermediate Handling

1) Grade and curve territories

a) Negotiate, stop at designated location(s) and restart train in the following situations as appropriate:

- Level territory with curve(s)
- Straight territory with light and heavy descending grade(s)
- Straight territory with light and heavy ascending grade(s)
- Light and heavy ascending and descending grades with curves
- Cresting grade
- Undulating grade
- Sag or dip territory
- Hump, knoll or hogback territory

b) Demonstrate cycle braking and dynamic braking coupled with automatic braking in the above territories

c) Demonstrate manual sanding, as appropriate

2) Power assistance

a) For operations in consort with remote control equipment (RCE), helper and pusher operations, perform the following activities:

- Set up and check out configuration prior to employment
- Employ brakes and power functions
- For RCE, switch between independent unit, partially independent unit and multiple unit modes of operation

b) Operate as a pusher or helper unit

3) Braking assistance

a) Set up and check out repeater relay system

b) Operate in consort with repeater relay system

c. Special Handling

1) Demonstrate procedures for restarting train after penalty brake application

2) Take appropriate action following a failure of dynamic brakes on a moderate to heavy downgrade

3) Recommend and/or take appropriate actions to correct the following operating difficulties:

a) Engine shutdown
b) Excessive air pressure leakage
c) Brakes overcharged
d) Broken brake pipe
e) Sticking brakes
f) Sanding malfunction/failure
g) Traction motor malfunction/failure
h) Overheated journal bearing(s)

d. Communications

1) Employ train radio to send and receive messages in the following modes of operation:

a) Locomotive to dispatcher
b) Locomotive to caboose or outside crew

2) Comply with written or oral train orders

3) Execute work order/defect report

4. Mission Completion

a. Leave main track and proceed to yard

b. Stop train at appropriate destination and secure power consist; then shutdown and secure power consist

c. File appropriate operational and maintenance reports with proper authorities

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DUNLAP *and* ASSOCIATES, INC.

DARIEN, CONNECTICUT 06820

One Parkland Drive
Area Code 203 655-3971
In N.Y.C., WYandotte 3-2464

Executive Offices
Eastern Division

SANTA MONICA, CALIFORNIA 90404

1454 Cloverfield Boulevard
Area Code 213 829-1866
Western Division

MANHATTAN, KANSAS 66502

200 Research Drive
Area Code 913 JEfferson 9-3565
Agri Division

HARVARD, MASSACHUSETTS 01451

Route 2 and 110
Area Code 617 456-8337
Boston Technical Facility