ADVANCED ENGINEER TRAINING

Pre-course Workbook

must be taken into consideration following a release of the brakes if a minimum reduction is required in subsequent brake applications.

When making a brake application in a state of false gradient, it is important to know the brake pipe taper. Any brake application must be sufficiently below the rear end brake pipe pressure to ensure an effective minimum application throughout the train.

False gradient is affected by the amount of recharge times between brake applications

The Pressure Maintaining Brake Valve (Relay Valve) is an excellent tool and provides a great advantage in train control. The pressure maintaining brake valve will hold the brake pipe pressure at a given level.

Amount of False Gradient = true gradient minus present charge of last car
Example:

88 psi highest normal rear car BPP	(true gradient)
- 85 psi current rear car BPP	(false gradient)
3 psi	(amount of false gradient)

Example:
If your train is fully charged to 90 psi with a true gradient of 0, to obtain maximum brake cylinder pressure on the rear of the train you would make a 26 psi reduction which would yield 64 psi brake cylinder pressure.

As you can see from each additional reduction and release from a false gradient it would yield less brake cylinder on the rear of the train. It is imperative that the engineer is aware of the brake pipe pressure at the rear of the train at all times in order to ensure an effective reduction and avoid the possibility of an unintentional release.

Retainer Valves

USE OF RETAINER VALVES

Retaining valves must be used on any descending grade when in the judgment of the locomotive engineer their use is considered to be necessary. Handles will be placed in the **high-pressure** position on **loaded** cars only. On Canadian Pacific Railway only (EX) and (HP) positions are the only positions utilized.

When traversing with retaining valves applied:
Do not exceed **20 mph** or travel for more than **20 minutes**. If time is reached stop and cool wheels for **10 minutes**.

4. Draft Force

Draft Force results from tension exerted on draft gear and couplers as a train is stretched. Maximum allowable steady state draft force is 300,000 lbs. for cars with grade C steel. Cars equipped with grade E steel may withstand a steady state force of up to 400,000 lbs. The alloy or chemical makeup used in making the steel determines its grade and tensile strength. Peak draft force (run-out) in excess of 100,000 lbs. may cause train separation and damage to lading or equipment.

5. Retarding Force

Retarding Force describes the force used to slow or stop a train. Retarding forces may be exerted with air brakes, dynamic brakes, grade, track curvature, wind, etc. Retarding force exerted by air brakes becomes more effective as a train decelerates.
When operating high tonnage, high horsepower trains, engineers must use good judgment in the application of train braking and effective retarding forces. Two keys to successfully controlling train speed are split service air brake applications and the planned use of dynamic braking.
Braking should be planned well in advance of a stop or slow down to provide a gradual reduction in speed. The low power split reduction technique provides a rapid and even propagation of train brakes. It also acts as a buffer against adverse slack action and a means of minimizing fuel use. Proper utilization of low power / split reduction technique requires throttle position in notch 4 or less when making a minimum brake pipe reduction of 5 to 7 pounds. Through the initial quick service feature of the control valves, this application yields approximately 10 - 12 pounds of brake cylinder pressure on the freight cars. This application propagates at a rate of 400 - 600 feet per second. Additional reductions of 2-3 lbs. may be made in 30 second intervals if needed. Heavy initial reductions of 12 lbs. or more will result in heavy brake cylinder pressure on the head end of the train causing the rear of the train to run in. Using this technique could cause adverse slack action that is severe enough to result in damage to equipment, lading, or derailment.

When dynamic brakes are used, it is important to apply them gently at first to gather train slack. After the train is bunched, care should be given to minimize slack action as much as possible. Typically, in dynamic braking, 300 amps or 30klbs tractive effort, provides enough braking force to start bunching the slack on a train that is descending a grade.

Attention must also be given to maintaining steady state buff forces within limits when braking a train. Dynamic Brake Factor is utilized to keep these forces at 200,000 lbs. When traversing through temporary speed restrictions, additional restrictions apply.

While braking a train in descending grade territory, over temporary speed restrictions, it is preferable to have braking distributed lightly over the entire train length rather than concentrated at the head end with dynamic braking only. When approaching a temporary speed restriction, dynamic brakes should be reduced prior to entering the speed restriction. Sudden increases or decreases of train speed should be avoided in these locations and train speed should remain constant throughout the temporary speed restriction.

String-Lining is caused when high draft forces are exerted on a train operating on curved track.

Jackknifing occurs when high buff forces within a train cause it to buckle outward on both tangent track or on curved track in forward or reverse movements.

The potential for failure due to **stringlining** and **jackknifing** is exacerbated by low speed high amperage operation. Another critical factor is train make-up. When empty or lightweight cars are placed ahead of heavy loaded cars the potential for train handling problems is increased. Empty cars have a smaller value in the vertical component or denominator of the L/V ratio. Damaging levels of in train forces are more likely to develop if the engineer does not utilize care in the application of tractive effort or retarding forces.

FLAT SPOT PREVENTION

Flat spots are a costly but preventable problem on Canadian Pacific Railway. Listed below are six keys to flat spot prevention:

1. Proper locomotive brake tests
2. Easing down on brake cylinder pressure just prior to stops
3. Maintaining proper brake cylinder pressure
4. Inspecting for hand brakes prior to movement
5. Ensuring brakes are released prior to movement
6. Careful planning of stops

Planned stops: Sufficient time should be allowed for the proper application of train air brakes. This is an important factor in preventing severe in-train forces or slack action from occurring. Additionally, this will minimize the events that are associated with causing flat spots. In both yard and road service it is essential that engineers control all train movements safely and efficiently. Good communication and understanding of these requirements among all crew members is essential in preventing flat spots or wheel damage from occurring.

TRIP PLANNING AND TRAIN HANDLING

The professional locomotive engineer has an array of responsibilities associated with his or her daily tasks. Information is provided to the engineer from the time of call to the end of their tour of duty. Organizing, processing, retaining, and applying the information they receive are only a few of the engineer's integral duties. How well this information is analyzed is crucial to the engineer's performance and success in handling the train. Some suggestions to help in the processing of this information is as follows:

- Look over the TYES train information.
    - Locomotive consist information
    - Tonnage profile (Locate loads and empties)
- Make any necessary computations early.
- Write down any critical information.
    - Know the location of hazardous material & dimensional shipments
    - Fill out Crew to Crew Form Q-8065 with pertinent information
- Have meaning of information shared and understood by all members of the crew.
    - Job briefing
- Have needed information from charts ready before it's needed
    - Be prepared
- Keep all information accessible

Throttle

Proper handling of the throttle in starting and controlling your train is critical to minimizing in-train forces and maximizing fuel conservation.

Which method engineers decide to use in starting a train is dependent upon several factors. Some of the things to be considered are as follows:

- Type of locomotives being used (Throttle response characteristics)
- Type of train
- Weight and length of the train
- Amount of slack in the train (Example: 100 car train approx. 50 ft.)
- Weather
- Grade
- Rail conditions
- Proximity of curves in relation to head end location
- Train marshaling

Since all of these factors are variable, specific instructions for starting various types of trains is difficult to provide. However, there are general concepts that should be taken into consideration and are addressed in the following pages.

Tractive Effort is the force exerted by a locomotive on a track for the movement of a train. Today's high horsepower locomotives may develop tractive effort that can exceed the draft rigging limitations.

For example: A locomotive consist of 4 SD-40's with 24 powered axles is capable of exerting a starting tractive effort of over 350,000 lbs. with average adhesion conditions. This force is well above the accepted maximum of 300,000 lbs. for cars used in normal interchange service.

Strength of Freight Car Couplers:

- Cars used in normal interchange service: Grade C steel. 300,000 lbs.
- Cars used in unit trains: Grade E steel. 400,000 lbs.

Dynamic Brakes

Efficient train handling is achieved with a thorough understanding of train braking choices.

USE OF THE DYNAMIC BRAKE

Dynamic braking can often be used to effectively control train speed on descending grades during slow downs and stops. Because dynamic braking concentrates the retarding force at the head end of a train, similar to independent braking, there are practical limits to the amount of braking that should be done with the dynamic brakes. Extreme care must be exercised to avoid the development of excessive buff forces.

A heavy concentration of braking forces can create high levels of lateral force which will, in effect, develop high L/V (lateral /vertical) ratios. Excessive forces developed by this may result in a derailment or gradual deterioration of the track structure. If the forces occur at turnouts, crossovers, points of sharp curvature, or other types of track irregularity the impact magnifies. Train makeup can have a substantial impact on these forces and consequently merit attention by the engineer. Any combination of light cars, long cars, coupled to heavy short or long cars, or couplers misaligned, specifically at locations near the engines, will increase the possibility of damage or derailment if care is not exercised.

WHAT IS DYNAMIC BRAKING

Dynamic braking is a method of braking used to control train speed on descending grades and to reduce train speed when stopping. This is accomplished by changing mechanical power, developed by the momentum of a moving locomotive, into an effective retarding force. Electrical circuits are set up to change the traction motors into generators. The resistance set up in each traction motor is a magnetic field through which the traction motor armature must rotate. The movement of the dynamic brake handle controls the strength of the magnetic field and resultant effectiveness of the brake. Rotation of the armature through the magnetic field generates braking current. This current is sent to the resistor grids that are fan cooled, where the excessive electrical current is dissipated as heat.

MAXIMUM RETARDING FORCE

The retarding force produced by locomotives operating in dynamic will vary between locomotive models. For instance at low speeds, the SD60's extended range dynamic brake is noticeably different than a SD40's standard range brake. In the following pages of this Chapter, we will identify and explain the various dynamic brake types and features that are available. We will also identify some of the characteristics of the newer AC locomotives and their dynamic capabilities.

The following depicts a similar chart that represents the culmination of standard range locomotives, extended range locomotives, and also the capabilities of modern AC locomotives that we currently have in our fleet. It should be noted the ability of the AC locomotives to generate retarding forces down to zero miles per hour. This offers the engineer a multitude of tools to control train operation during slow downs and stops on both level track and descending grade territories.

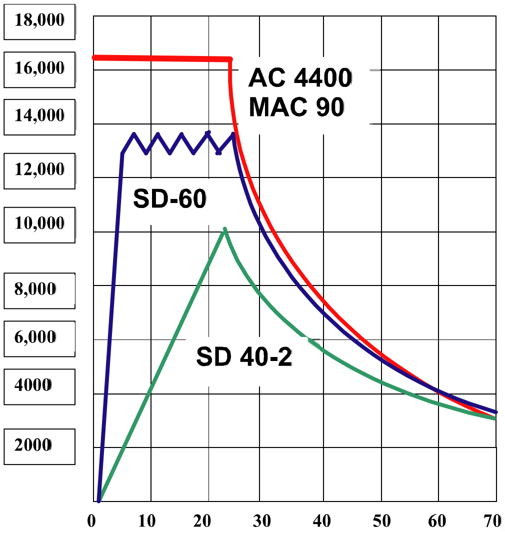

Figure 5. Dynamic Braking capabilities of various locomotives

STANDARD CAPACITY & HIGH CAPACITY DYNAMIC BRAKES

Older locomotives (SD40 & SD40-2s) are generally equipped with standard capacity dynamic brakes and the GM locomotives (SD60s) and GE AC (4400) are equipped with high capacity dynamic brakes. Dynamic braking force capacity is limited by the number of locomotive axles capable of producing dynamic braking. A dynamic brake retarding force of 10,000 pounds is equivalent to a dynamic brake factor of 1.

Example: A standard SD 40 can produce 60,000 pounds of retarding force or a DB factor of 6. Some locomotive types or models can produce more retarding force per axle and others produce less. See Figure 5.

NOTE: The maximum retarding force on Canadian Pacific Railway developed in dynamic braking must not exceed 200,000 pounds (referred to as a dynamic brake factor of 20). Engineers must ensure their locomotive consist does not exceed a DB factor of 20. Refer to chart in Section 1 of the General Operating Rules (GOI) for DB factors of various locomotives in service on Canadian Pacific Railway.

Standard Capacity

Standard capacity locomotives (SD40 & SD40-2) can produce up to 10,000 pounds of retarding force per axle or 60,000 pounds of force per 6 axle unit (DB Factor 6). A four unit consist of SD 40s has the potential to produce up to 240,000 pounds of retarding force (DB Factor 24).

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

DYNAMICS AND TRAIN AIR BRAKES

When the available dynamic brake force will not properly control the speed of the train, air brakes should be applied as well as the dynamic brake. **When using this technique it is recommended that you apply 50 to 75% dynamic brake and a sufficient automatic brake reduction to balance the train.** This method will allow the dynamic brake to be operated at a level in which it will be flexible enough to control any changes in speed due to the physical characteristics of terrain. Train brake applications should be used in conjunction with dynamic brakes at locations where it is desirable to reduce head end buff forces such as going through temporary speed restrictions and turnouts. The locomotive brakes must be actuated manually to protect against a dynamic brake interlock malfunction. When actuating, allow 4 - 6 seconds for each unit in the locomotive consist.

Fuel Conservation

TRAIN FUEL EFFICIENCY

Train fuel efficiency is a measurable quantity. It is defined as the amount of fuel required to do the work, divided by the useful work done by the locomotive. In other words, it is the ratio of the number of litres or gallons of fuel used divided by the work performed by the locomotive(s). The definition of work requires that the locomotive exerts a force on the train and the train must move. If there is neither effort exerted by the locomotive nor any train movement there is no work performed by the locomotive and its fuel efficiency is zero.

On CPR, a bulk train is more fuel efficient than a non-bulk intermodal or mixed freight train, because train fuel efficiencies are measured by litres/1000 gross ton miles (which are converted to Imperial Gallons in Canada) or US gallons/1000 gross ton miles (GTMs).
For example, train fuel efficiency resulting from bulk and non-bulk (intermodal) traffic are as follows:

	In Canada (Litres)	**In USA (US Gallons)**
Bulk	= 3.721L/1000 GTM	0.98/1000 GTM
Intermodal	= 6.15L/1000 GTM	1.63/1000 GTM

NOTE: A bulk train will consume more fuel that a non-bulk train over the same territory, but a bulk train has more tonnage moved per fuel used, consequently being considered to be more fuel efficient.

Consider train fuel efficiency another way. Train fuel efficiency is proportional to the horsepower per ton factor. That is, the lower the value of the HP/Ton factor, the more fuel efficient the train. For example, bulk trains with HP/Ton factors of less than 1.0 are more fuel efficient than those trains which have a designated HP/Ton factor of 2.7.

If Fuel Trip Optimizer (FTO) is available, it must be utilized.

LOCOMOTIVE/TRAIN MARSHALING

There are three primary considerations to be made:

Locomotive Power Considerations - The locomotive consist should be made up so that it has the lowest horsepower per ton ratio needed to provide the required level of service. This means that the locomotive consist should not be over powered or under powered for the train it is to be pulling. Factors such as terrain and weather must also be considered when determining how much power will be needed.

If there are excess locomotives in the consist, they should be isolated or shut down when the opportunity to conserve fuel is present. An isolated locomotive is still consuming fuel, but at the idle

four during this process on most locomotives (see note below). Once main reservoir pressure exceeds 105 psi, the throttle should be immediately returned to idle.
If available, you may also charge the train using yard air sources, and thus avoid using the onboard compressors.

SPEED CONTROL

Speed control means not only operating the train at safe, rule compliant speeds, but also at speeds which make the most efficient use of fuel. The two most important factors are:

Acceleration requires more fuel than maintaining a constant speed.

Maximum Speed – A fast moving train uses more fuel than a slow moving train. This is because the engines must work harder to sustain the higher speed, and the high speed creates increased aerodynamic drag, which puts a further load on the engines.

Train fuel efficiency is directly proportional to diesel engine efficiency and train speed. Simply, when comparing identical trains, the slower train is more fuel efficient than the faster train.
To make the most efficient use of fuel you should operate the train at a constant speed as much as possible. Engineers should avoid excessive throttle modulation, excessive dynamic braking, unnecessary stops, unnecessary slow downs, and short bursts of speed. The main idea of speed control is to operate at a constant speed over as great a distance as possible.

SANDING

In some conditions, it may be necessary to use the sanding feature to apply sand to the rail. This improves adhesion, but causes the engines to work harder and consequently to use more fuel to overcome the increased rolling resistance. It should therefore be used sparingly. Excessive sand dumped on the rail is classified as hazardous waste

BRAKING METHOD SELECTION

Controlling train speed and slack during a trip requires braking. The type of braking you select has a significant impact on fuel consumption. The following list describes the efficiency of the different types of braking available:

Dynamic Braking – This method should be considered the primary choice of retardation as it combines good braking power and fuel efficiency.

Contour Braking/Throttle Modulation – To slow the train, reduce the throttle in conjunction with track grade and curvature. It is fuel efficient, and a method of slowing down with minimal in train forces.

Low Power Split Reduction – It is a series of throttle reductions and small automatic brake applications to reduce train speed. It is not as efficient as the previous methods, but it is the more efficient than a heavy brake application at high throttle positions.

Power Braking – This method is not fuel efficient. Power Braking is anytime you are pulling a train with the automatic brake applied. Not allowed in throttle 4 or higher.

Chapter 4: Train Handling

Instructions

To complete this Chapter first read the content in Sections 1, 2, 6, 7, 10 & 11 of the U.S. General Operating Instructions (GOI) and the content in Chapter 4 in the AET book. Then complete questions and scenarios below.

AET QUIZ

1. What may heavy retarding force be exerted with?
    a. Dynamic brake
    b. Engine brake
    c. Both a and b
    d. None of the above

2. Well in advance of a slow order, the engineer should:
    a. Consider the tonnage and make-up of the train
    b. Consider the grades involved
    c. Start the slowdown well ahead of the restriction
    d. All of the above

3. What does distributed braking refer to?
    a. Concentrating all braking action on the head end
    b. Having maximum braking on the rear of the train
    c. Spreading the retarding force through the train
    d. None of the above

4. A small percentage increase in speed results in a much larger percentage increase in lateral force.
    a. True
    b. False

5. What should you do when cresting a grade?
    a. You should always try to maintain maximum authorized speed
    b. Time the decrease in throttle as the head end crests
    c. Allow the throttle 10 seconds in idle before going to DB
    d. Both b and c are correct

14. Maximum dynamic braking must now be limited not to exceed ________ pounds of retarding force.
    a. 110,000 lb.
    b. 180,000 lb.
    c. 200,000 lb.
    d. 230,000 lb.

15. What should you do when changing from power to dynamic braking?
    a. Wait ten seconds in set-up before increasing dynamic brake.
    b. Wait ten seconds in idle before going to dynamic brake setup.
    c. Make at least a 10 PSI brake pipe reduction.
    d. Alert the dispatcher to your intentions.

16. What should you do when using the automatic brake in conjunction with the dynamic brake?
    a. Actuate the independent brake at least 4 - 6 seconds per unit.
    b. Pause for a moment in suppression.
    c. Ensure amperage does not exceed 650.
    d. Compute the tons per operative brake to determine stopping distance when using combined braking methods.

17. What is the procedure if you are approaching a railroad crossing at grade in throttle and your speed is over 25 mph? Why is this necessary?

    ____

    ____

    ____

18. What is procedure if you are below 25 mph and you are approaching a crossing at grade with throttle in position 3?

    ____

    ____

19. You have two SD 60s and you have been moving at 10 mph for 30 minutes. How much longer can you operate at this speed?

    ____

SCENARIO E: EN ROUTE – DYNAMIC BRAKING

Train # 199 is now negotiating a descending grade for 7 miles with several road crossings, sidings, and one railroad crossing. You have previously devised a strategy to handle the train and are prepared. You have reduced the throttle and are planning to use a combination of air brakes and dynamic brakes.

You are to take the siding at No Where for a meet. You enter the siding at the applicable speed and stop for the red signal at the opposite end.

After 1 hour and meeting train #398, the signal changes, and you are en route again. At MP 62.5, the signal for the Canadian National Railway Interlocking indicated proceed. The descent was uneventful, and now approaching a segment that has several temporary speed restrictions. The first one located at MP 72.0 to 73.0.

Instructions: From the given scenario, answer the following questions.

1. What factors should you consider while negotiating this descending grade?

   ____

   ____

2. What is the proper technique in reducing the throttle when setting up for dynamic braking and why is this important?

   ____

   ____

3. What is the significance of waiting 10 seconds with the throttle in idle before moving the handle to dynamic brake set up?

   ____

4. What is the maximum DB retarding force that may be utilized on Canadian Pacific?

   ____

5. If it was necessary for you to reduce DB factor in his consist, how would you do so?

   ____

   ____