NEVADA STATE RAILROAD MUSEUM

CARSON CITY, NEVADA

CONDUCTOR HANDBOOK

2010

Conductor

Description: The Conductor is a volunteer who is responsible for the safe operation of the train to which he is assigned. He is responsible for the safety of the passengers aboard his train and in addition, shall demonstrate concern for their comfort and enjoyment. Conductors shall be responsible for seeing that trains operate on schedule and that adequate and responsible personnel are on hand to carry out such operations. Conductors are responsible for supervising the members of the Train Crews assigned to them, assuring that they perform their duties efficiently, safely and courteously.
Conductors will be familiar with proper equipment operation. They are expected to observe the operations of other members of the train crew in order to prepare for advancement.

Conductor's duties include:

1. Presenting the daily pre-operation Safety Briefing.
2. Following the instructions in the NSRM Conductor's Handbook.
3. Working in a safe manner.
4. Being responsible for and giving direction to Crew Members.
5. Directing the Engineer in moving the locomotive onto and away from the turntable.
6. Inspecting the outside of the train at the start of the day to check for anything that may cause an unsafe condition. This inspection may be assigned to and performed by an experienced Brakeman. However, the Conductor remains responsible for this inspection.
7. Performing brake-tests.
8. Assigning experienced Crew Members to instruct Trainees.
9. Assigning Crew Members to Car Attendant positions and as Switchmen.
10. Ensuring that Crew Members know, and perform, their assigned duties.
11. Assisting in the boarding and detraining of passengers.
12. Communicating to the Engineer where to make a Station Stop.
13. Communicating to the Engineer when the train is ready to depart after any stop.
14. Taking charge in any emergency situation. He must know emergency procedures and take appropriate actions including calling emergency services if necessary.

Requirements: Thirty hours as a Brakeman, followed by thirty hours as a Conductor Trainee, recommendation by the Training Conductor after completing the training in a satisfactory manner as well as successful completion of the written Conductor Qualification Test. The Road Foreman (or his designee) will then schedule two (2) complete days of observation and testing with the Crew Member before any decisions are made on certification. The decision to certify or not to certify will be made jointly by the Road Foreman (or his designee) and the Crew Chief. If the Crew Member should not be certified he will be given the reasons for that decision. After further training and with the recommendation of the Training Conductor, the Crew Member may request that he be rescheduled for observation and testing. Notice of any decertification will be given in writing. A Conductor must be at least 21 years old.

All positions require that the Crew Member have passed the NSRM Rule Book / Safety Test. Attendance at the annual Safety Meeting is required to maintain status as a Crew Member.

In addition to the items described in this manual, a candidate for the position of Conductor, Fireman or Engineer must also demonstrate over time that he is always aware of the operating environment of the museum and that he consistently exercises good judgment about the needs of the public, the needs of the train crew, the operation of the train, and the importance of safety. The Road Foreman (or his designee) and the Crew Chief must make this subjective evaluation and both must agree to the promotion of a candidate to any of these positions.

1.0 INTRODUCTION

This Conductor’s Handbook is intended to provide the basic information needed to perform the duties of a Conductor. Any update of the safety information will be noted in the text as a revision from the previous issue of the handbook.

Appearance is important. Conductors must be neatly dressed and groomed.
You should at all times wear your volunteer’s name badge.
It is preferred, but not mandatory, that Conductors be dressed in dark pants, white shirt, tie, vest, conductor’s cap, and jackets or coats when required by the weather.
The Conductor may also be dressed in the typical NSRM uniform:
a museum logo shirt, jeans or overalls, a railroader’s cap and jackets or coats when required by the weather. If possible, a Conductor Trainee should obtain a Conductor’s Cap in order for the Engine Crew to easily identify him as the person authorized to give signals. Again, this is preferred but not mandatory.
Footwear is an important factor in safety. Wear work boots/shoes with soles and heels firmly attached and heels that are not excessively worn. Suitable footwear around shops, tracks, and moving equipment does NOT include high-heeled boots or shoes, sandals, low quarter slip-on shoes or tennis shoes.

You should carry your NSRM Rulebook at all times while on duty.

2.0 SUMMARY OF CONDUCTOR'S DUTIES

The Conductor has overall responsibility for the train and its operation. All persons on a train are subject to the Conductor's instructions. The protection of passengers and trains is of the first importance and Conductors must not allow other duties to interfere therewith. The Conductor must be familiar with the contents of the reference documents.

It is the Conductor's responsibility to provide a safe and pleasant experience for the passengers. This is accomplished by making sure that the environment is safe, that all operations are performed safely, that the passengers behave in a safe manner, and that the passengers are reasonably comfortable and informed.

2.1 CREW CALL

The Conductor must see that all members of the crew report for duty at the prescribed time. All crew positions must be filled by qualified individuals. Each train must have a complete crew to begin operations.

2.2 PRIOR TO FIRST RUN

It is the Conductor's responsibility to ensure that the following items are accomplished at the beginning of the day:

A) Check for any General Orders that may be in effect and be sure that all crew members are prepared to comply with them.*

B) All doors through which any portion of the train will pass must be fully open to the maximum of their travel and secured with a keeper.

C) The turntable must be aligned with the track occupied by the locomotive.

D) Once the locomotive has been moved from the turntable, the turntable must be locked in place to keep unauthorized persons from moving it.

E) Ensure that the train is prepared for removal from its storage location in the building. All brakes except for the rear of the caboose should be released.

F) Supervise the coupling of the engine to the train.

G) Make the brake test. (See: 2.4 below)

H) Check the installation of the marker lights.

I) Be certain that the rear annex doors are securely closed.

J) Take control of the movement of the train as it taken to the depot for its first run of the day.

K) Prepare the train for passengers.

***General orders are posted just inside the Restoration Shop door and are also available on the Friend's website: www.nsrm-friends.org/nsrm141.html**

2.3 PRIOR TO MOVING THE TRAIN

Prior to moving the train, the Brakeman and the Engineer have inspections to perform. It is the Conductor's responsibility to ensure that these inspections have occurred.

In addition he should:

A) Look for any dragging equipment or any debris lodged in the undercarriage.

B) Make sure that all brake lines are properly connected and that angle cocks are in the proper position.

C) Check couplers and verify that all pins are in the locked position

E) Verify that all wheels, chocks and skates have been removed.

F) Make sure that all hand brakes have been released.

2.4 BRAKE TEST

There are two types of Brake Test used at NSRM:

Minimum: Once the engineer has pumped up the brake line, open the angle cock at the end of the car furthest from the engine to ensure that there is pressure throughout the length of the train. Hold the end of the brake hose tightly so that it will not flail around and injure anyone. This will put the train into 'emergency' and will require that the brake line be recharged. Be sure to close the angle cock after this test.

Full: Give the engineer the 'brake test' signal. He will apply the brakes. Check to see that all brakes apply along the entire train. Give the engineer the 'release brakes' signal. He will release the brakes. Check to see that all brakes release along the entire train. You may then proceed with regular train operations. This is the preferred option.

2.5 SAFETY BRIEFING

The Safety Briefing will cover any restrictions on operations including, but not limited to, equipment operating condition, and special passenger requirements. The Conductor should also review any General Orders that may be in effect, safety instructions, the need to remain hydrated and reminders of any changes to be made in crew member's responsibility.

Although the Crew Chief makes crew assignments prior to the day's operation, the Conductor makes the final decision for all train crew assignments. You must be sure that crew members are trained and certified for the jobs to which they are assigned.

This is the opportunity to assign experienced Crew Members to teach Trainees. The initial Car Attendant, Brakeman and Switchman assignments should also be made at this time.

2.6 LOADING PASSENGERS

The following items are Car Attendant responsibilities and the Conductor should be sure that they are being met:

A) Assist passengers onto the step and instruct them to hold the hand rail as they climb the steps.

B) If a passenger might have difficulty negotiating the stairs, offer to assist them, and offer use of the wheelchair lift for loading.

C) If needed, assist other crew members in loading passengers requiring the wheelchair lift.

D) Observe what people are carrying, and if consumables other than water are noted, inform the passengers that only water is allowed to be consumed aboard the train.

E) Keep approximate count of how many seats remain in your car and do a walk through head count as the car reaches capacity.

F) Just before the train leaves, make sure that all passengers are seated and in the case of the open car that the car crossover is raised and secured.

2.7 DURING THE RUN

The Conductor will determine that the passengers are safely aboard and the train is ready to depart. He will announce a clear "All Aboard" and will give a high-ball to the Engineer to permit the train to leave the station. Once the run is under way, the Conductor should make an inspection of all of the cars. He should observe that the Switchman has properly thrown the switches once the train has passed. As the train goes down hills he should observe braking to ensure that no wheels tend to slide. And at all times, he should stay aware of the operation of the train and observe Crew Members at their duties (especially if there are trainees in any of the crew positions), and maintain communication with the Engine Crew.

2.8 END OF THE TRACK RUN AROUND OPERATION

When the train reaches 'the hole' and once the train is clear of the fouling point of Switch 5, the Conductor will give a *stop* signal to the Engineer. Once the train has stopped, he will then detrain while the Brakemen at each end of the train go about their jobs. The Conductor will observe as the locomotive is uncoupled and is pulled away from the train.
When it is safe to do so, the Conductor will close the angle cock at that end of the train and will inspect the end of the car to see if there are any defects.
While the engine is moved to the siding and run around the train the Conductor will walk the length of the train, inspect the train and check to see that switches are properly thrown and that the angle cock at the rear of the train has been opened. He will watch as the Brakeman couples the engine to the train and makes up the air. When the Brakeman returns operational control of the train to him, the Conductor will perform a brake test, check both sides of the train for people or obstacles and only then signal the train to proceed.

2.9 END OF THE RUN

As the train arrives at the depot, the Conductor will signal the Engine Crew for a safe stop.
If it is necessary to refill the tender with water he should assign Brakemen to do the job and instruct them to control the stopping of the engine. He should inform Car Attendants that this will occur so they can ensure that passengers remain safely in their seats until the train has made its final stop, and that the engineer has blown the whistle to indicate that the brakes have been set.

Once the train is stopped at the depot and Car Attendants have helped passengers to detrain the Conductor should make Car Attendant & Brakeman assignments and assign a Switchman for the next run.
The Conductor should be sure that enough crew members are available at the train while others are eating.

2.10 END OF THE DAY

A) Before the last run the Conductor will assign one Brakeman to ensure that the wheelchair lift is put away and that all doors and windows at the Wabuska Depot are securely fastened and locked before the train is returned to storage. Generally Museum Staff will be the last to leave the depot and will close and lock the doors and windows but a member of the Train Crew must check that this has been done. Check the 'Special Event' sign and assign a member of the crew to take it down and store it in the depot if necessary.

B) Once all the passengers have detrained following the last run, the train will be pushed to the passing siding at the end of track. The Conductor will assign two Brakemen to ride the rear of the train as it is moved. They must stand on the rear step of the caboose, clearly visible to the enginemen, and will signal to proceed or stop as appropriate. They must be sure that the grade crossing is safe to enter and cross. Brakemen must also be especially aware of the positions of all track switches and must not permit the train to pass through any switch that is not correctly aligned.

C) The locomotive will be moved to the rear of the train and will push the train up the hill and into the building for overnight storage. The Conductor will assign two Brakemen to ride the front car of the train, clearly visible to the enginemen, and will signal to proceed or stop as appropriate. They must be especially aware of the positions of all track switches and must not permit the train to pass through any switch that is not correctly aligned.

D) The Conductor will assign a crew member, under the direction of the engine crew, to sand the flues as the train is pushed up the hill.

E) Any door through which any portion of the train will pass must be fully open to the maximum of its travel and secured with a keeper.

F) Marker lamps must be removed from the rear of the caboose before the train is moved into the building.

G) Supervise the Brakeman as the train is pushed into its place in the building. The rear of the train must clear the back door and the front of the train should be clear of the gate within the building so that both the gate and the door can be securely closed and latched.

H) The Conductor will accompany the locomotive as it is moved from the back of the building until it stops short of the turntable. The Conductor will provide signals to the Engineer to ensure safely putting the engine onto the turntable, turning it to the proper track and bringing it to its position near the Annex building.

I) The Conductor will assign a Brakeman to move the switcher onto and off the turntable in order to push the locomotive into its parking stall. Because the locomotive is considered to be 'blue-flagged' once it is on the stall track, this movement shall be made only after the engine crew indicates that it is safe to do so.

J) Once the locomotive and switcher have been moved from the turntable, the turntable must be locked in place to keep unauthorized persons from moving it.

K) Car Attendants and Brakemen should aid in wiping the locomotive clean after the day's activities.

L) Assist the Engine Crew in parking the locomotive and the switch engine inside the building.

M) Call Simplex/Grinnell (the fire alarm company) and notify them that a hot locomotive has been put into the building. [1-888-746-7539]

N) Record your volunteer hours for the museum's records.

2.11 SPECIAL EVENTS SIGN

Any time that the Steam Train operates for the public is a Special Event.

The Conductor should ensure that a member of his crew displays the 'Special Event' sign on the frame adjacent to Carson Street. At the end of the day's operations the Conductor should see that the sign is taken down and stored in the depot. If the train is to be operated on the next day the sign can be displayed over night.

2.12 BUILDING SECURITY

All buildings on the NSRM property must be secure at the end of each day.

A) It is the responsibility of Museum Staff to lock the doors on the public restrooms as well as to close and lock the doors and activate the alarm at the Interpretive Center.

B) Before the last run the Conductor will assign one Brakeman to ensure that the wheelchair lift is put away and that all doors and windows at the Wabuska Depot are securely fastened and locked before the train is returned to storage. Generally Museum Staff will be the last to leave the depot and will lock the doors and windows but a member of the Train Crew must check that this has been done.

C) The Conductor will ensure that the Annex Building is secure.

1. The Turntable must be secured and padlocked when switching moves are complete.
2. All overhead doors must be closed and the chain which operates each door secured with a keeper.
3. The gate inside the building that separates the public area from the non-public area is to be closed, and if possible, latched.
4. Check that the doors to the Archive Office area are closed and locked.

D) The Enginemen are responsible to ensure that all shop doors and the door behind which the locomotive is stored are closed and locked. In addition, before they leave the building, they must check that the compressor has been turned off and that the other doors of the building remain secure.

E) The last person to leave the Nelson House must ensure that trash has been removed, all of the windows are closed and latched, and the door is locked.

2.13 ELECTRONIC DEVICES

The Federal Railroad Administration has issued Emergency Order #26 regarding the use of electronic devices by train operating crews while on duty. Though our operation is not governed under rules of the FRA, adoption of this rule enhances safety of crews and passengers and as such is made part of our operating rules.

A) These rules are effective when on a moving train, when duty requires any crewmember to be on the ground, when a crewmember is riding rolling equipment during a switching operation and when any other employee of the railroad is assisting with the preparation of the train.

B) Hearing aids and digital watches are permitted.

C) Personal electronic/electrical devices must be turned off with any earpiece removed from the ear. This includes, but is not limited to, cell phones, audio players and video players. Any of these devices located in the locomotive cab not only must be turned off but also stored in the engineer's or fireman's seat box.

D) Exceptions:

1. In the event of an emergency or other problem the Conductor or his designee may use a cell phone to contact Emergency Services or museum staff. This cell phone should remain on but is for duty use only.

2. These devices may be used while on a designated lunch break.

3. As long as it does not interfere with the performance of their other duties crewmembers may take pictures using a digital camera.

4. These devices may be used if all crewmembers have been notified that operations have been suspended.

E) The Nevada State Railroad Museum does not supply any electronic/electrical devices for use during train operations.

F) The FRA has provided the attached flow-chart for your information.

FRA EO 26 – Electronic and Electrical Device Flow Chart

Use of Personal or RR supplied electronic/electrical devices may NOT interfere with RR operating employees performance of safety related duties

Use of RR supplied electronic/electrical devices *PROHIBITED* when:

Other RR Operating Employee*

On a moving train unless:

- Authorized for business purpose
- A safety briefing is held
- Crew agrees it is safe to do so

or

- Authorized business purpose within the body of a passenger train or RR business car

Outside the cab unless:

- Not fouling a track
- No Switching Operation is underway
- No other safety related duties
- All crew members have been briefed that operations are suspended

Locomotive Engineer/ RCO

On a moving train

or

When a duty requires any crew member to be on the ground

or

When a crew member is riding rolling equipment during a switching operation

and

During any period when another employee of the RR is assisting in preparation of the train

Personal electronic/electrical devices *MUST BE TURNED OFF* with earpiece removed when: (other than a hearing aid device)

All RR Operating Employees*

On a moving train

or

When a duty requires any crew member to be on the ground

or

When a crew member is riding rolling equipment during a switching operation

and

During any period when another employee of the RR is assisting in preparation of the train

Exceptions:

(1) May use digital storage and display function of personal or RR supplied device to refer to RR rule, SI, TT, other directive, if authorized by RR operating rule or instruction;

(2) May use Personal or RR supplied device as necessary to respond to an emergency involving the operation of the RR;

(3) Engineer/RCO may use electronic control systems and information displays presented within locomotive cab or on RCO transmitter including functions associated with controlling switches;

(4) Under authorized conditions of 49 CFR 220, may use a RR supplied/authorized device in lieu of RR radio, to conduct train or switching operations;

(5) May refer to a digital timepiece to ascertain time of day or verify accuracy of speed indicators.

Note:

WHILE ON DUTY use of personal electronic/electrical devices for other than voice communication is prohibited except as noted above

*Means a person performing duties subject to 49 U.S.C. 21103,"limitation on duty hours of train employees."

2.14 STANDARD CLOCK

The Standard Clock is in the Restoration Shop. This railroad runs on Pacific Time. The Standard Clock is set automatically via radio signal several times a day. You should adjust your watch to be within one minute of the Standard Clock. Compare your watch with that of the Engineer and the remainder of your crew. Use of a digital watch is permitted.

2.15 EXCEPTIONS

All of the above describe the regular activities of an ordinary day's operation. **<u>There is *never* an ordinary day's operation</u>.** Be prepared for changes in your work necessitated by safety concerns, a different routine (such as Santa Train or night operation), differing equipment or the needs of the museum.

BE FLEXIBLE

<u>BE SAFE</u>

3.0 EMERGENCIES

For all emergencies, it is the responsibility of the Conductor to determine the nature and severity of the emergency, to determine whether to call 9-1-1, to direct train crew actions, and to contact and coordinate with the Nevada State Railroad Museum staff and Emergency Services as needed.

3.1 PROCEDURES

<u>Know where the First Aid Kits and Fire Extinguishers are at all times.</u>

A current copy of the Emergency Response Procedures should be available at all times. These procedures are intended to be strong guidelines, but be sure that common sense is used to interpret the intent of these procedures.

To aid in the interpretations, keep in mind that the order of priorities is:

1) Safety of Passengers and Crew first;
2) Equipment and railroad property second.

Emergency Responses are divided into six general categories:

1) Medical emergencies;
2) Fire (smoke);
3) Uncooperative passengers;
4) Obstruction problems;
5) Mechanical problems;
6) Observed (from the train) problems.

3.2 CONTACTING EMERGENCY SERVICES

Prior to the first run, the Conductor must determine the location of a cell phone to be used for emergency calls. If the Conductor does not have a cell phone, it may be necessary to borrow one from a crew member if he needs to contact Emergency Services.

Train Air Brake Description and History

Part I

There is a lot more to train air brake systems than meets the eye. The following was posted on the Internet by Bob MacDowell and is as good a description as we have seen. Thanks Bob.

Early Train Brakes

The first train brakes were very simple. To stop the train, you blew a certain pattern with the engine whistle and brakemen would jump from car to car setting handbrakes. Brakemen, needless to say, had trouble getting life insurance...

The next generation of brakes added a compressor to the locomotive, and a brake pipe running the length of the train, connected between cars with gladhands, which were symmetrical "non-gendered" connectors that were latched together by hand and would separate by themselves if pulled on. The brake pipe was connected to an air cylinder on each car, which pulled on the handbrake chain when the brake pipe was pressurized.

In other words, charge the brake pipe with air, and the brakes went on. This worked MUCH better than brakemen, but it still took a long time to pump all that air back to the cars. And, all it took was a parted hose or other failure anywhere in the brake system to cause the system to fail entirely.

Westinghouse's Invention

A guy named George Westinghouse didn't like the direct air brake either, and he invented a thing called a triple valve. This valve, and a reservoir on the car, inverted the behavior of the direct air brake: charging air into the pipe charged the system and released the brakes, and draining air from the brake pipe applied the brakes. He now had a much more responsive system that was fail-safe. It worked, and became the basis of the modern air brake.

The triple valve attached directly to the brake pipe, then had a connection to the reservoir, and to the brake cylinder. It was called "triple valve" not for the three connections, but for its three modes:

- **Charging**

  At rest, the Westinghouse brake system has no air in it. So the air brakes in the train must first be charged. As air is pumped down the brake pipe by the locomotive, the triple valve directs it into the car's reservoir, where it is held for use in applying the brakes later. When the system is fully charged, brake pipe and all the reservoirs in the train will be at a pressure designated by the railroad, for this discussion let's say 70 pounds.

- **Applying**

  When the engineer wants to apply the brakes, he sets the brake handle such that air is removed from the brake pipe. When the triple valve sees brake pipe pressure fall, it allows reservoir air into the brake cylinder, and the brakes apply. It's pretty simple; if you reduce the brake pipe pressure 5 pounds to 65 pounds, the triple valve transfers air into the cylinder until the reservoir drops to 65 pounds. Due to the relative volumes of the reservoir and (properly adjusted) cylinder, this will put 12.5 pounds of air into the cylinder.

  A 10 pound reduction will give 25 pounds of cylinder application (by reducing the reservoir from 70 to 60). The maximum braking, then, is a 20-pound reduction, which puts 50 pounds in the cylinder, and leaves 50 pounds in the reservoir. At this point, pressure in the reservoir and cylinder are equalized, and that's as hard as the system will brake. Even if the brake pipe pressure is reduced further, nothing more will happen.

- **Releasing**

  Once the brakes are applied, an *increase* in pressure told the triple-valve to release the brakes. When it saw an increase, it would vent the cylinder to atmosphere, and start to recharge the reservoir.

(In modern brakes there are two kinds of release actions: Direct Release, in which *any* increase in pipe pressure kicks the brakes off fully. Freight brakes work this way. Graduated Release, in which a partial increase provides a partial, proportional release. This is used in passenger trains, though the valve becomes much more complicated.)

Westinghouse's triple valve improved response times, because it didn't need to move all the air needed to apply the brakes. It only had to move enough air to carry a **signal** to the triple valve, telling it to apply or release. But still, the signal took awhile to work its way down the brake pipe. This would be improved later...

Improvements: Emergency

An Emergency feature was an early addition to Westinghouse's technology. This added a second reservoir, and made the control valve more complicated, but it added the means to make a harder application of the brakes. And, with a propagation feature called "Quick Action", it made them apply very quickly too.

"Emergency" adds a fourth mode to the brake system. A **rapid** decrease in brake pressure signals the valve to immediately throw the "works" into stopping the train. Including the full contents of a second, larger reservoir, called the "Emergency" reservoir. (The original reservoir is now called the "Auxiliary" reservoir.)

Most freight cars use a "duplex" reservoir, which are two cast halves separated by a steel plate. The steel plate is shaped like a dome inside, which makes the emergency half of the reservoir larger. A tab sticks out of this steel plate, one side labeled "aux" and the other "emerg" so the sides can be identified.

In normal operation, the emergency-equipped control valve operates just like the original triple valve, except, of course, that it also charges the emergency reservoir. But part of the valve is designed to detect a rapid drop in pressure, which trips the emergency mode. The valve will then dump the entire contents of both reservoirs into the cylinder, and when pressure equalizes, there will be nearly full system pressure in the cylinder, 63 pounds or so on a 70-pound brake pipe pressure. This is as hard as the brakes will go, and will often lock up the axles at low speeds, skidding flats in the wheels. The force of an emergency application can also damage lading or even derail the train!

An emergency stop is now the default action almost anytime there's a brake failure. Any rupture in the brake pipe will cause an emergency application, as will a defective brake valve pejoratively called a "kicker" or "dynamiter" (which puts the whole train in emergency.)

The reason a defective valve could disable a whole train, is that part of the "Emergency" feature is another feature called "Quick Action". Since an emergency application requires a rapid drop in brake pipe pressure, there needs to be a way to make sure the drop remains rapid, even far back in the train. The locomotive alone can't do that; by the time the pressure drop got 100 cars back, it would not be so rapid.

So each valve repeats and **propagates** the effect of the emergency brake. That's what Quick Action does. When the valve goes into emergency, Quick Action vents the brake pipe itself, thus causing a rapid drop, amplifying the emergency action and making sure the next valve goes into emergency too.

That also means that if a valve is defective, and produces what is called an "Undesirable Emergency Application" (UDE), the entire train will follow suit.

When conductors rode in cabooses, they knew of four reasons for their train unexpectedly going into emergency:

1. **An air hose has parted.**
2. **The train has broken in two.**
3. **One of the cars is a "kicker".**
4. **The head end is about to hit something.**

Usually, they didn't think too much about the cause before grabbing a handhold; the slack action from an emergency brake could tear the stove out of the wall. But as soon as they stopped, they'd radio to the head end "All stopped!" which gives the engineer some idea of how many pieces the train is in.

The AB Freight Control Valve

The Westinghouse "AB" control valve is, essentially, the modern brake. It has all the brake features discussed so far. While there have been technological upgrades ("ABD" to "ABDW" to "ABDX") the basic packaging is standardized, and worth talking about.

The "AB" control valve consists of a pipe bracket, to which all piping connections are made, and two control valve portions (the "Service" and "Emergency" portions) which bolt to the pipe bracket with three bolts. Each of the three pieces weighs about 65 pounds, which is (conveniently?) just light enough to be shipped by UPS.

The beauty of the system is its ease of maintenance. The two portions (which are quite complex inside) simply bolt off; and you don't rebuild them, you just ship them off to someone who does it for you for about $120. Add ten dollars worth of gaskets and filters, and a field diagnostic, and you've done 16-year brake service on a railroad car. The hard part is cutting out the stencil which says "C.O.T.S. 1/4/94" (Clean, Oil, Test and Stencil)

The pipe bracket does not just unbolt; there are pipes attached to it. The five pipes are Brake Pipe, Cylinder, Auxiliary Reservoir, Emergency Reservoir, and Retainer. The last one deserves some explanation.

The retainer is a way of "keeping" some of the brake application, even after the brakes are released. When an AB brake releases cylinder pressure, it vents it out the "retainer" port. On most cars, this leads to a retaining valve located on the side of the car. The retaining valve retains pressure in the cylinder when the control valve tries to release it. It can be set for "direct", which lets the air out directly, or "retain 10 pounds" which keeps the last 10 pounds of pressure in the cylinder.

This is used to descend long grades: with the retainers turned up, the cars will hold ten pounds of brakes even while the brakes are fully released and recharging. More advanced retainers added two more settings: retain 20 pounds, and slow release, which would release fully but took about 90 seconds to do it.

On cars that didn't use the feature, a screen was put over the retaining valve port to keep wasps from building nests in the control valve.

More Improvements: the ABD valve

The ABD valve added two features which made brake response faster, but they worked mostly like AB valves, and were, of course, compatible. However, they were completely different internally.

The old AB valve used technology of 100 years ago inside the valve: small pistons moved brass slide valves, aligning or blocking ports to make the valve function. They had to be lubricated with graphite, and there were always problems with scoring and leakage. With the ABD valve, rubber diaphragms (like in a car's fuel pump) replaced the pistons, and sliding shafts with rubber gaskets replaced the brass slide valves. Although, they did basically the same thing.

Two functional features were added to AB and newer valves: Quick Service and Quick Release. Both worked like Quick Action, manipulating brake pipe pressure to propagate the brake commands more quickly.

Quick Service propagates the effect of a service application. When it sees a pressure drop of 1-1/2 pounds or so, it vents some more brake pipe pressure to atmosphere, assuming a 5-pound application. This means that the next valve sets brake more quickly, and so on.

Quick Release does the same thing, for releases. When it sees an increase in pipe pressure, it adds some air from the emergency reservoir into the brake pipe. This increases the pressure some more, and all in all makes the train release much more quickly.

But... remember the trouble with "Kickers" and the Quick Action feature, where one car could put an entire train into emergency? The same thing can happen here, but now one car can release the brakes on an entire train. This caused major problems until it was learned that certain ways of handling the brake were causing it.

Picture, if you will, a train crew on a hill, trying to uncouple the locomotives from a train. The engineer makes a heavy brake reduction, which causes air in the pipe to move toward the locomotive. Then, a brakeman closes the angle cock (the valve between cars that closes off the brake pipe) on the first car, so they can uncouple. Normal enough, but watch what happens in the brake pipe...

Air is moving through the brake pipe, and suddenly the air passage is shut. But air has momentum, and it's still moving toward the locomotive. So it piles up at the closed angle cock, a little pneumatic traffic jam. And as it does, the pressure at that spot in the brake pipe, increases. Guess what the control valve in that car does. It releases.

This wasn't a problem with the AB valve; at most one or two cars at the front of the train would release. But the Quick Release feature changes all that, because it propagates the release back through the train. That knocks the brakes off the second car, which knocks the brakes off the third, and so on...

By the time the crew realizes it, their entire train has released, and it's headed down the mountain.

Education has pretty much fixed the problem; wait until air has stopped moving before closing the angle cock; or leave it open a bit so air continues to drain.

Braking down Hills

Diesel locomotives have two brake systems: an air system, which is independent of the train brake; and dynamic brakes, which use the main drive motors as generators, and discard the generated energy out large resistor banks.

Ideally, braking down long grades is done with dynamic brakes. They never overheat or wear out. Realistically, some help from air brakes on the train is often needed, and that's done either by normal use of the brakes, or by stopping and turning up retainers.

I won't talk about how air brakes perform over long periods of use, but I believe they are sufficiently leak-resistant that they can make it down the hill without needing to stop and recharge. However, if the engineer repeatedly applies and releases the air brakes, he will eventually drain the auxiliary reservoirs on the cars (but the emergency reservoirs will be intact...) If an engineer foolishly does this, he may need to use emergency to stop the train. Then he will need to turn up enough retainers to hold the hill, and release the brakes, and pump air into the system until it is recharged. While he waits, the trainmaster will show up and cuss him out, of course...

There have been several rounds of evolution on locomotive brake stands (which together with the control-valve-like Distributing Valve, control the locomotive's and the train's brakes) The very early varieties had three positions: Running (which charged the brake pipe up to a set pressure), Apply (which discharged the brake pipe), and Lap (which did nothing to the pipe). An engineer would move the handle to "Apply" until he got the pressure he wanted, and then he would move the handle to "Lap". Unfortunately, leakage would tend to reduce the pipe pressure further, which would cause the cars to set the brakes harder and harder. This caused problems on hills, as described above.

The most common contemporary model is the "26", which is a pressure maintaining brake. Meaning, if you set the handle to 65 pounds, it will automatically hold it at 65, even against leakage. This solves the hill problem.

Before the invention of the pressure maintaining brake, engineers would improvise one by adjusting the "feed valve", which is the pressure regulator that feeds the brake system, and thus determines maximum brake pipe pressure. That's supposed to be set at whatever brake pipe pressure the railroad runs as a practice (70, 80 or 90 pounds) and left there. To maintain pressure in their brake pipes, engineers would dial the feed valve to the application they wanted (say, 60 pounds) then let leakage bring it down to that. The feed valve, thinking 60 pounds was the running pressure, would dutifully hold the brake pipe there, against leakage. It was illegal but it mostly worked.

Runaways

Seems like there's a runaway in almost every train movie. But there's only about four ways a runaway can happen, given modern brakes...

1. The crew forgot to charge the system in the first place. If you couple onto a string of cars that's been stored for a week, there's no air in it. If you then haul it away without hooking up air or doing an air test, you could lose your train simply because the locomotive is the only brake on the train.
2. The "Quick Release" bug, described above. If there's anyone on board capable of pulling an emergency cord, it'll stop the train.
3. Going so fast down a hill that you gain kinetic energy faster than your brakes can get rid of it. Like running down a steep hill.
4. The brake pipe gets "bottled up" behind the engine. Either an angle cock vibrated shut (very unlikely) or the brake pipe fell on the tracks and got bent and pinched shut in a way that "bottled the air" in most of the train, so there aren't enough responding brakes to stop it (also very unlikely, but it HAS happened...) Again, if there's anyone back there to pull the emergency cord, they'll stop the train. Or, if there's enough brake pipe leakage in the bottled portion, one of the valves will go into Quick Service, and will cascade at least a minimum application...

These are all pretty bizarre, and they just don't happen much. And when they do, it's in the paper.

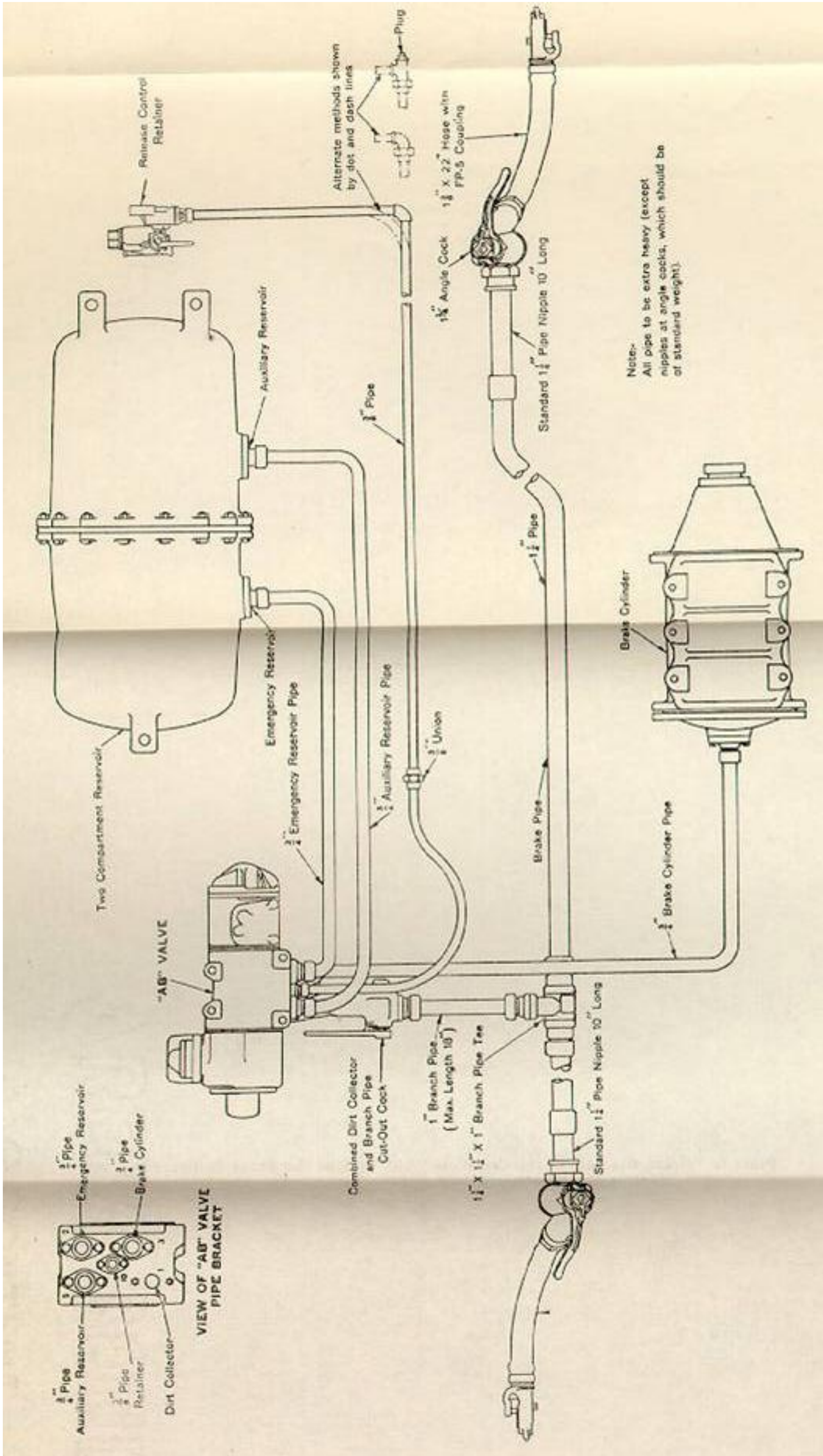
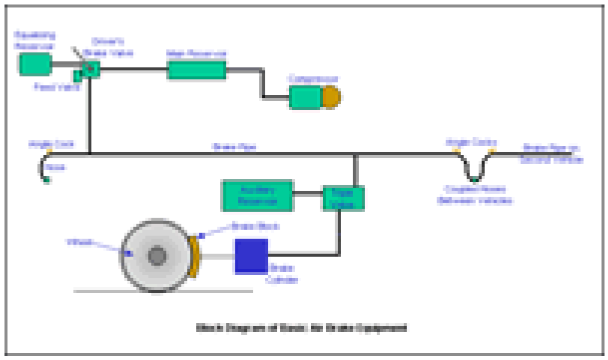


Plate 10 Piping Diagram of the Complete "AB" Freight Car Brake Equipment

Train Air Brake Description and History
Part II

Article and images by [Piers R. Connor](#).



The air brake is the standard, fail-safe, train brake used by railways all over the world. In spite of what you might think, there is no mystery to it. It is based on the simple physical properties of compressed air. So here is a simplified description of the air brake system.

Basics

A moving train contains energy, known as kinetic energy, which needs to be removed from the train in order to cause it to stop. The simplest way of doing this is to convert the energy into heat. The conversion is usually done by applying a contact material to the rotating wheels or to discs attached to the axles. The material creates friction and converts the kinetic energy into heat. The wheels slow down and eventually the train stops. The material used for braking is normally in the form of a block or pad.

The vast majority of the world's trains are equipped with braking systems which use compressed air as the force to push blocks on to wheels or pads on to discs. These systems are known as "air brakes" or "pneumatic brakes". The compressed air is transmitted along the train through a "brake pipe". Changing the level of air pressure in the pipe causes a change in the state of the brake on each vehicle. It can apply the brake, release it or hold it "on" after a partial application. The system is in widespread use throughout the world.

The Principal Parts of the Air Brake System

Compressor

The pump which draws air from the atmosphere and compresses it for use on the train. Its principal use is for the air brake system, although compressed air has a number of other uses on trains..

Main Reservoir

Storage tank for compressed air for braking and other pneumatic systems.

Engineer's Brake Valve

The means by which the engineer controls the brake. The brake valve will have (at least) the following positions: "Release", "Running", "Lap" and "Application" and "Emergency". There may also be a "Shut Down" position, which locks the valve out of use.

The "Release" position connects the main reservoir to the brake pipe. This raises the air pressure in the brake pipe as quickly as possible to get a rapid release after the engineer gets the signal to start the train.

In the "Running" position, the feed valve is selected. This allows a slow feed to be maintained into the brake pipe to counteract any small leaks or losses in the brake pipe, connections and hoses.

"Lap" is used to shut off the connection between the main reservoir and the brake pipe and to close off the connection to atmosphere after a brake application has been made. It can only be used to provide a partial application. A partial release is not possible with the common forms of air brake; particularly those used on US freight trains.

"Application" closes off the connection from the main reservoir and opens the brake pipe to atmosphere. The brake pipe pressure is reduced as air escapes. The engineer (and any observer in the know) can often hear the air escaping.

Most engineers' brake valves were fitted with an "Emergency" position. Its operation is the same as the "Application" position, except that the opening to atmosphere is larger to give a quicker application.

Feed Valve

To ensure that brake pipe pressure remains at the required level, a feed valve is connected between the main reservoir and the brake pipe when the "Running" position is selected. This valve is set to a specific operating pressure. Different railways use different pressures but they generally range between 65 and 90 psi (4.5 to 6.2 bar).

Equalizing Reservoir

This is a small pilot reservoir used to help the engineer select the right pressure in the brake pipe when making an application. When an application is made, moving the brake valve handle to the application position does not discharge the brake pipe directly, it lets air out of the equalizing reservoir. The equalizing reservoir is connected to a relay valve (called the "equalizing discharge valve" and not shown in my diagram) which detects the drop in pressure and automatically lets air escape from the brake pipe until the pressure in the pipe is the same as that in the equalizing reservoir.

The equalizing reservoir overcomes the difficulties which can result from a long brake pipe. A long pipe will mean that small changes in pressure selected by the engineer to get a low rate of braking will not be seen on his gauge until the change in pressure has stabilized along the whole train. The equalizing reservoir and associated relay valve allows the engineer to select a brake pipe pressure without having to wait for the actual pressure to settle down along a long brake pipe before he gets an accurate reading.

Brake Pipe

The pipe running the length of the train, which transmits the variations in pressure required to control the brake on each vehicle. It is connected between vehicles by flexible hoses, which can be uncoupled to allow vehicles to be separated. The use of the air system makes the brake "fail safe", i.e. loss of air in the brake pipe will cause the brake to apply. Brake pipe pressure loss can be through a number of causes as follows:

- A controlled reduction of pressure by the engineer
- A rapid reduction by the engineer using the emergency position on his brake valve
- A rapid reduction by the conductor who has an emergency valve at his position
- A rapid reduction by passengers (on some railways) using an emergency system to open a valve
- A rapid reduction through a burst pipe or hose
- A rapid reduction when the hoses part as a result of the train becoming parted or derailed.

Angle Cocks

At the ends of each vehicle, "angle cocks" are provided to allow the ends of the brake pipe hoses to be sealed when the vehicle is uncoupled. The cocks prevent the air being lost from the brake pipe.

Coupled Hoses

The brake pipe is carried between adjacent vehicles through flexible hoses. The hoses can be sealed at the outer ends of the train by closing the angle cocks.

Brake Cylinder

Each vehicle has at least one brake cylinder. Sometimes two or more are provided. The movement of the piston contained inside the cylinder operates the brakes through links called "rigging". The rigging applies the blocks to the wheels. Some modern systems use disc brakes. The piston inside the brake cylinder moves in accordance with the change in air pressure in the cylinder.

Auxiliary Reservoir

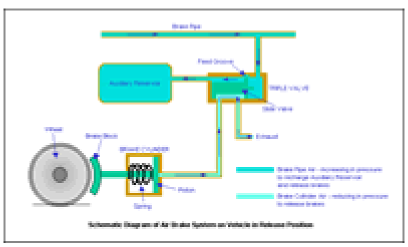
The operation of the air brake on each vehicle relies on the difference in pressure between one side of the triple valve piston and the other. In order to ensure there is always a source of air available to operate the brake, an "auxiliary reservoir" is connected to one side of the piston by way of the triple valve. The flow of air into and out of the auxiliary reservoir is controlled by the triple valve.

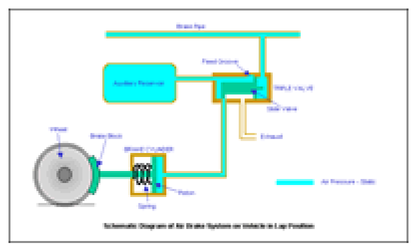
Brake Shoes

Brake shoes are the friction material which is pressed against the surface of the wheel tread by the upward movement of the brake cylinder piston. Often made of cast iron or some composition material, brake shoes are the main source of wear in the brake system and require regular inspection to see that they are changed when required.

Brake Rigging

This is the system by which the movement of the brake cylinder piston transmits pressure to the brake blocks on each wheel. Rigging can often be complex, especially under a passenger car with two shoes to each wheel, making a total of sixteen. Rigging requires careful adjustment to ensure all the shoes operated from one cylinder provide an even rate of application to each wheel. If you change one shoe, you have to check and adjust all the shoes on that axle.





Triple Valve

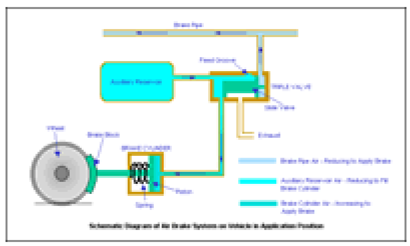
The operation of the brake on each vehicle is controlled by the "triple valve", so called because it has three functions - to release the brake, to apply it and to hold it at the current level of application. The triple valve contains a slide valve which detects changes in the brake pipe pressure and rearranges the connections inside the valve accordingly. It either:

- **recharges the auxiliary reservoir and opens the brake cylinder exhaust,**
- **closes the brake cylinder exhaust and allows the auxiliary reservoir air to feed into the brake cylinder**
- **or holds the air pressures in the auxiliary reservoir and brake cylinder at the current level.**

Operation on Each Car

Brake Release

The engineer has placed the brake valve in the "Release" position. Pressure in the brake pipe is rising and enters the triple valve on each car, pushing the slide valve provided inside the triple valve to the left. The movement of the slide valve allows a "feed groove" above it to open between the brake pipe and the auxiliary reservoir, and another connection below it to open between the brake cylinder and an exhaust port. The feed groove allows brake pipe air pressure to enter the auxiliary reservoir and it will recharge it until its pressure is the same as that in the brake pipe. At the same time, the connection at the bottom of the slide valve will allow any air pressure in the brake cylinder to escape through the exhaust port to atmosphere. As the air escapes, the spring in the cylinder will push the piston back and cause the brake blocks to be removed from contact with the wheels. The train brakes are now released and the auxiliary reservoirs are being replenished ready for another brake application.



Brake Application

The engineer has placed the brake valve in the "Application" position. This causes air pressure in the brake pipe to escape. The loss of pressure is detected by the slide valve in the triple valve. Because the pressure on one side (the brake pipe side) of the valve has fallen, the auxiliary reservoir pressure on the other side has pushed the valve (towards the right) so that the feed groove over the valve is closed. The connection between the brake cylinder and the exhaust underneath the slide valve has also been closed. At the same time a connection between the auxiliary reservoir and the brake cylinder has been opened. Auxiliary reservoir air now feeds through into the brake cylinder. The air pressure forces the piston to move against the spring pressure and causes the brake blocks to be applied to the wheels. Air will continue to pass from the auxiliary reservoir to the brake cylinder until the pressure in both is equal. This is the maximum pressure the brake cylinder will obtain and is equivalent to a full application. To get a full application with a reasonable volume of air, the volume of the brake cylinder is usually about 40% of that of the auxiliary reservoir.

Lap

The purpose of the "Lap" position is to allow the brake rate to be held constant after a partial application has been made.

When the engineer places the brake valve in the "Lap" position while air is escaping from the brake pipe, the escape is suspended. The brake pipe pressure stops falling. In each triple valve, the suspension of this loss of brake pipe pressure is detected by the slide valve because the auxiliary pressure on the opposite side continues to fall while the brake pipe pressure stops falling. The slide valve therefore moves towards the auxiliary reservoir until the connection to the brake cylinder is closed off. The slide valve is now half-way between its application and release positions and the air pressures are now is a state of balance between the auxiliary reservoir and the brake pipe. The brake cylinder is held constant while the port connection in the triple valve remains closed. The brake is "lapped".

Lap does not work after a release has been initiated. Once the brake valve has been placed in the "Release" position, the slide valves will all be moved to enable the recharge of the auxiliary reservoirs. Another application should not be made until sufficient time has been allowed for this recharge. The length of time will depend on the amount of air used for the previous application and the length of the train.

Additional Features of the Air Brake

What we have seen so far is the basics of the air brake system. Over the 130 years since its invention, there have been a number of improvements as described below.

Emergency Air Brake

Most air brake systems have an "Emergency" position on the engineer's brake valve. This position dumps the brake pipe air quickly. Although the maximum amount of air which can be obtained in the brake cylinders does not vary on a standard air brake system, the rate of application is faster in "Emergency". Some triple valves are fitted with sensor valves which detect a sudden drop in brake pipe pressure and then locally drop brake pipe pressure. This has the effect of speeding up the drop in pressure along the train - it increases the "propagation rate".

Emergency Reservoirs

Some air brake systems use emergency reservoirs. These are provided on each car like the auxiliary reservoir and are recharged from the brake pipe in a similar way. However, they are only used in an emergency, usually being triggered by the triple valve sensing a sudden drop in brake pipe pressure. A special version of the triple valve (a distributor) is required for cars fitted with emergency reservoirs.

Distributors

A distributor performs the same function as the triple valve; it's just a more sophisticated version. Distributors have the ability to connect an emergency reservoir to the brake system on the vehicle and to recharge it. Distributors may also have a partial release facility, something not usually available with triple valves.

A modern distributor will have:

- **a quick service feature - where a small chamber inside the distributor is used to accept brake pipe air to assist in the transmission of pressure reduction down the train**
- **a reapplication feature - allowing the brake to be quickly re-applied after a partial release**
- **a graduated release feature - allowing a partial release followed by a holding of the lower application rate**
- **a connection for a variable load valve - allowing brake cylinder pressure to adjust to the weight of the vehicle.**

North American Freight Train Brakes
Part III

by Al Krug

Each freight car has an air tank (reservoir) on it. This reservoir is charged with compressed air from the locomotive's air compressor thru the train line brake pipe. That's the air hoses you see between the cars that go 'Kapowssssh' when you uncouple them. After the initial charging of the reservoirs, the brakes can be set by REDUCING the pressure in the brake pipe. Compressed air from each car's reservoir pushes on the brake cylinder piston to apply the brakes on the car. If you have no air in the reservoir then you've got no brakes, you've got a run away.

Now if you are not technically oriented or don't understand the meaning of psi (pounds per square inch air pressure) you may as well give up right here and be satisfied with the above description. If you understand compressed air and have a high boredom threshold then read on.

OK, how are the brakes controlled? That is the job of the so called "triple valve" on each car. Basically this valve compares brake pipe air pressure and car reservoir air pressure. If the brake pipe pressure is HIGHER than the reservoir pressure, the triple valve moves to the RELEASE position. In this position it vents any brake CYLINDER air to atmosphere thus releasing the brakes. It also connects the BRAKE PIPE to the RESERVOIR so brake pipe air pressure can begin recharging the reservoir. This is the situation you are in when you are CHARGING the brake system sitting in the yard waiting for a brake test ("pumping up the air"). So now the locomotive's diesel engine is turning an air compressor that is pumping air thru my brake valve into the brake pipe of the train, back thru the train and thru the triple valves of each car into the reservoirs. This takes a lot of air. It takes anywhere from 15 minutes to an hour to charge a train depending on its length and how leaky the air hose couplings are.

On the railroad I work for the standard brake pipe pressure is 90 psi. Once the cars' reservoirs are charged to the same pressure as the brake pipe (90 psi) the triple valve on that car will move to the neutral or LAP position. The brakes are now ready to be used, either on the road or for an air brake test. Now suppose I want to set the air brakes. What I do is move the brake valve handle from the RELEASE & CHARGE position to the APPLICATION position. This disconnects the loco's air compressor from the brake pipe and opens a small hole to vent brake pipe air pressure to atmosphere. This venting of brake pipe air causes the brake pipe pressure to drop slowly. On each car the triple valve is watching the brake pipe pressure and the reservoir pressure. Remember when the system was charged, both reservoir and brake pipe were at 90 psi. Now with the brake pipe pressure dropping, the triple valve senses that the brake pipe is LOWER than the reservoir, this is a signal to the triple valve on that car to move to the APPLY position. In the apply position it connects the RESERVOIR air pressure to the BRAKE CYLINDER. This air pressure pushes the brake cylinder piston out and applies the brakes. Meanwhile up in the cab I watch my gauges and when I get the brake pipe pressure lowered to where I want it I put my brake valve in neutral or LAP. Lap simply seals the brake pipe, letting no more air out and not letting any air compressor air into it. Let's say I "made a 10 pound set". This means I reduced the brake pipe air pressure from 90 psi to 80 psi then lapped the brake valve. Remember the triple valve on the car was watching the brake pipe air pressure and as soon as it dropped below reservoir pressure it moved to the APPLY position and allowed reservoir air to flow into the brake cylinder. This flow of air from the car reservoir to the cylinder will of course lower the pressure in the car

reservoir. Remember that the triple valve always watches the pressure in the brake pipe and the reservoir. It allows air to flow from the reservoir into the brake cylinder UNTIL THE RESERVOIR PRESSURE LOWERS TO THAT OF THE BRAKE PIPE PRESSURE.

Now once again the reservoir and brake pipe are equal pressure so the triple valve returns to LAP position. Both now have 80 psi. But now all that air that flowed from the reservoir to the cylinder has applied the brakes on that car. The volume of the reservoir is about 2.5 times the volume of the brake cylinder. So to lower the reservoir 10 psi, from 90 to 80, enough air flowed from the reservoir into the cylinder that it put 25 psi (2.5 times 10 psi reduction = 25 psi) in the brake cylinder.

Simple isn't it? I now have the choice of leaving the brakes applied to control speed or stop, or I can make another reduction to get heavier braking, or I can release them. Let’s say I want to slow down faster than I am so I want more braking. I move my brake valve to the application position and lower the brake pipe another 5 psi from 80 to 75 psi. The triple valves on the cars sense once again that the brake pipe (75psi) is LOWER than the reservoir (80psi). So they move to the APPLY position and allow more reservoir air to flow into the cylinder until the reservoir is the same pressure as the brake pipe (75psi). The brake cylinder pressure goes up and so the braking effort goes up. Because of the 2.5 ratio of reservoir volume to cylinder volume this 5 psi reduction results in (2.5 times 5psi =) 12.5 psi more braking pressure. This is on top of the 25 psi already there for a total of 37.5 psi brake cylinder pressure. Notice that if this air brake system is fully charged, it is "fail safe". That is, anytime the brake pipe air reduces, the brakes apply. Thus if a train comes uncoupled or an air hose bursts, the brakes apply fully, automatically. The amount of braking relies on the amount the system is charged however.

When I no longer need the brakes I can release them. This is done by moving my brake valve to the RELEASE & CHARGE position. As before this simply connects the locomotive air compressors to the brake pipe and pumps air back thru the brake pipe raising its pressure back to 90 psi. The cars triple valves sense that the brake pipe (90psi) is HIGHER than the reservoir (75psi) and move to RELEASE position. This connects the brake cylinder to the atmosphere releasing the air pressure in the cylinder and thus releasing the brakes. It also connects the brake pipe to the reservoir to begin recharging the reservoir from the brake pipe. Notice there is NO GRADUAL release, the release is a complete release.

Tah-Dah! You now know the basics of air brakes. But as always in life there are complications. First of all, note that when the brakes released on the train cars the brake pipe was at 90 psi but the reservoirs were at 75 psi. Upon releasing the reservoirs BEGIN to recharge but that takes time. So for several minutes after releasing the brakes, the reservoirs are not fully charged and thus I do not have full braking available. Suppose I had made a total reduction of 15 psi as above, this reduced the brake pipe and reservoirs from 90 to 75 psi. I then release the brakes by raising the brake pipe back to 90 psi.

Suppose 1 minute later I want to set the brakes again? The brake pipe is at 90 psi but the reservoirs may have only re-charged from 75 psi to 79 psi! Now if I make a 10 psi reduction of the brake pipe from 90 to 80 what does the car triple valve see? It sees 80 psi in the brake pipe and 79 psi in the reservoir. The brake pipe is HIGHER than the reservoir so it stays in the release position! I get NO brakes! Nada! Zip! IF I reduce a further 5 psi to bring the brake pipe down to 75psi, the triple valve sees the brake pipe LOWER than the reservoir (79) so it goes to APPLY position. This once again allows reservoir air to flow into the brake cylinder until the reservoir pressure lowers to the brake pipe. The brake pipe is at 75 psi and the reservoir was at 79 psi so the

reservoir lowers 4 psi. The 2.5 volume ratio between the reservoir and brake cylinder means I got (2.5 times 4 psi =) 10 psi in the brake cylinder. Very little brakes where before with the same 15 psi reduction I got 37.5 psi in the cylinders! This is how most classic run-aways occur.

Imagine going down a long mountain grade, a dumb engineer makes several heavy sets and releases of the air brakes in a short period of time. He soon finds he has no brakes because there is very little air left in the reservoirs. This is known as "pissing away your air". Now, before you go tell the press at the scene of a run away train wreck that the train had a dumb engineer, allow me to state that there are other ways runaways can occur that are no fault of the engineer.

Another complication of this simple brake system is that a long train has a long brake pipe and all that pipe contains a lot of air. When I want to make a brake application by reducing the brake pipe pressure, it takes TIME to vent enough air to lower the pressure to where I want it. This can be managed under normal braking conditions but what about emergencies? They solved that by adding an emergency vent valve to each car. This valve watches the brake pipe air pressure. If the brake pipe pressure goes down SLOWLY the emergency valve does nothing, no matter how low the pressure goes. But if the pressure drops QUICKLY the emergency valve senses this and opens the car's brake pipe to the atmosphere. This quickly dumps the brake pipe air to the atmosphere at the car. In other words all the air does not have to go thru the entire brake pipe up to my valve in the loco for emergency. All I have to do is START the emergency application by venting brake pipe air at the head end QUICKLY. This causes the first car emergency valve to sense the fast drop and move into emergency. This vents all brake pipe air at that car quickly, the next car senses a fast drop and also goes to emergency, then the next and next and so on. Within seconds the entire train is in emergency, dumping all the brake pipe air at each car. You get a fast and full application of the brakes through out the entire train. If you are standing near a train when the loco uncouples you can hear these emergency valves vent the brake pipe pressure locally on the car you are next to. That car will go "Pssssssht". If you are standing some distance off to the side of the train you can hear each car trigger in succession as the "psssht, psssht, pssht, pssht" goes rapidly back along the train. These emergency vent valves stay open for about 2 minutes after triggering. This ensures the train is stopped before you can release the brakes.

Anything that causes a QUICK drop in brake pipe pressure at any car will trigger that car which in turn triggers adjoining cars and thus puts the whole train in emergency. This initial trigger could be the engineer, the conductor pulling his emergency valve in the caboose, the brakeman pulling his valve in the cab, the train or air hoses coming uncoupled, or an air hose bursting.

This is all well and good in theory but what about that doofus engineer described above that "pisses" away his air so there is little air in the reservoirs? He still gets very little braking in emergency, he just gets it quicker. To ensure that there is always air pressure on each car for an emergency application, they modified the basic system. They added a second reservoir to each car! The original reservoir we've discussed up to this point is called the SERVICE RESERVOIR because it is the one used in normal service braking. The new reservoir is called the EMERGENCY RESERVOIR because it is only used in emergencies. This emergency reservoir is charged with compressed air from the brake pipe just like the service reservoir. After the initial charging time in the yard it has 90 psi in it. This air is never used during normal braking. However, if I initiate an emergency application by making a QUICK reduction at my brake valve, each car emergency valve triggers just like before, but now it also connects the emergency reservoir air to the brake cylinder in combination with the service reservoir air. This ensures that there will be air pressure for an emergency stop.

By the way...When I make a service application of the brakes, I vent the brake pipe air thru a SMALL HOLE in my brake valve. This lowers the brake pipe air pressure slowly. When I want an emergency application of the train brakes I move my brake valve over to the emergency position. This is just a BIG HOLE that allows air to escape QUICKLY and that triggers the emergency valves on the train cars. That is where the terms "big hole 'em" and "He went to the big hole" come from, meaning an emergency application. Also the term "Dump the Air" means go into emergency. It comes from the fact that you initiate an emergency application and cause each cars' emergency valve to "dump the air" locally.

Regular service applications of the brakes are referred to as "set 'em up", "set the brakes" ,"set the air", or "squeeze the breeze".

The locomotives have air brakes just like the cars and they will apply when the brake pipe air pressure is reduced just like the car brakes. This is not always desired, especially when stretch braking with the throttle open and car brakes set to control the slack action. The engineer can prevent the loco brakes from applying at these times by depressing the independent brake handle and holding it down. This is called "bailing off the air" ,or more correctly, "actuating off the air". Locos also have "independent" brakes that you can apply on the locos only. This is straight air where the air pressure comes straight from the main air compressor reservoirs on the locos to the locos' brake cylinders. It is controlled by the position of the independent brake handle. It is used to apply the loco brakes only for switching or for holding a stopped train on level or low grade track. Of course each loco also has an air compressor & main air reservoirs on it. They are all connected by hoses to the lead loco so all units can help supply air. These main reservoir hoses and independent brake control hoses are the hoses you see between loco units. The big electrical jumper between units is a 27 wire cable that has control wires for trailing units' throttle, headlites, reverser, compressor control, generator field control, dynamic brake set up and control, engine alarm bell, sanders, etc.

You are now an expert on train brakes. There will be a quiz on Wednesday.

Quiz. (Is it Wednesday already?)

You have made a 10 psi brake pipe reduction on a fully charged one hundred ten car train. The brakes have applied. One car has a leak in its service reservoir. What happens to the brakes on that car? What happens to the brakes on the entire train?

Answer: (no peeking)

The key is to remember how the triple valve works. It senses the DIFFERENCE between the brake pipe pressure and the service reservoir pressure. If the brake pipe is higher than the reservoir the valve moves into release position. If the brake pipe is lower than the reservoir it moves into the apply position. If you have made a 10 psi reduction from 90 to 80 psi and the brakes have set, the reservoir and brake pipe are both now at 80 psi. As the reservoir slowly leaks the pressure drops, from 80 to 79 to 78 to 77 etc. As soon as the reservoir pressure leaks from 80 to 79 psi the triple valve "sees" that the brake pipe (80) is HIGHER than the reservoir (79). *IT WILL MOVE TO THE RELEASE POSITION and release the brakes on that car!!! Whoa! This is not good.* But you still have brakes on the other 109 cars of the train, hopefully.

More on train brakes.

Because during a normal service application, all the brake pipe air has to vent thru the loco's control valve, it takes a long time to get the brakes set through out the train. The pressure first drops near the front of the train and then drops further and further towards the rear. This causes the brakes to set up on the front part of the train before they set on the rear portion. This causes the rear end to run into the front end (slack action). So some smarty comes up with the idea of modifying the triple valve on the cars so that when a car first senses a drop of pressure, it opens a passage from the brake pipe to a small reservoir (a third reservoir called a "quick service reservoir"). This reservoir is sized such that it has the proper volume in relation to the car's brake pipe volume that filling it with air from the brake pipe will reduce the brake pipe 7 psi. That means when I make a 10 psi reduction, 7 psi worth of it is done at each car. This results in a faster (but not fast enough to trigger emergency) more even application of the brakes thru the train. It only works the first time, however, since after that the reservoir is filled and remains so until the brakes are released.

Because of the long brake pipe of a train and all those cut off valves at the ends of each car and other restrictions, it takes time to pump air back thru the train to release the brakes. As a matter of fact, as each car goes into release it begins recharging its reservoir from the brake pipe, consuming air from the brake pipe further slowing down the build up of pressure towards the rear. This results in the head end releasing first and causes problems with slack action as the front portion running free runs away from the rear portion still braked. In the early days they solved this problem by putting chokes in the pipes that carried air from the brake pipe to the reservoir on each car. This allowed a more rapid build up of air pressure in the brake pipe all the way to the rear of the train since each car reservoir was consuming brake pipe air at a slower rate due to the choke restriction as it recharged following a release. But as trains got longer and heavier even this was not enough and the chokes slowed down the initial charging of the trains in the yard and the recharge on the road.

So along comes Mr. Smart again. Like a Congressman and the social security fund, he can't stand to see a surplus go unused. Remember that emergency reservoir they put on each car? It was initially charged to 90 psi and never used if the engineer did not need an emergency application. Hmmmm. All that air there.... They modified the triple valve again so that when a car goes into release it:

1) vents the cylinder air to atmosphere releasing the brake as before,
2) connects the brake pipe to the reservoir to begin recharging as before, and now
3) connects the 90 psi emergency reservoir to the BRAKE PIPE to boost the brake pipe up quickly at each car.

This results in fast releases thru out the train length, but it depletes part of the emergency air available if you need it right away before it can recharge. Basically that's how train brakes work today.

Quiz #2.

With a whole train of this type of equipment, what are the answers to the two questions posed in quiz #1 with under the same conditions?

Answer:

Same as before the brake will release on the leaky car. However with this type of equipment that one leaky car will dump its emergency reservoir air into the brake pipe when it moves to the release position. This action will raise the brake pipe pressure on that car AND THE CARS NEXT TO IT! When the cars next to the leaky one see the brake pipe rise slightly above their service reservoir pressure, their valves interpret this as a release signal AND THEY ALSO MOVE TO RELEASE! Now they also dump their emergency reservoir air into their brake pipes and that triggers the cars next to them to release. Because of that one leaky service reservoir the entire train will release. It is for this reason that it is against the rules to "bottle the air", close the angle cock on the train, when uncoupling the engines.

Some other embellishments.

Retainers:

On long steep grades it may be necessary to set and release the brakes several times due to grade changes etc. But if you release the brakes on a steep hill the train immediately accelerates. If you immediately reset the brakes you get less braking than before because the car reservoirs have not had time to recharge. Because of the long recharge time on long freights a way was needed to keep the brakes applied on the cars yet allow them to recharge. Enter the retainer valve. When a triple valve moves to release it connects the reservoir to the brake pipe to begin recharging the reservoir from the brake pipe. It also vents (exhausts) the brake cylinder air to atmosphere to release the brakes. The retainer valve is mounted on the exhaust pipe of the brake cylinder and can restrict or close off that exhaust. This restriction holds some of the air in the brake cylinder thus keeping the brake applied even though the triple valve is in release where it allows recharging of the reservoirs. Retainer valves are completely manually operated, i.e. the train must be stopped (usually at the top of a long grade), the brakes released, and a crewman must walk back along the train. He turns the retainer valve on each car to the restricting position. Usually only a percentage of the cars are "retainered," just enough cars to keep the train from running away down the hill when the brakes are released and recharging during the run down the mountain. When the crewman is back aboard the train may proceed down the mountain. The air brakes work normally until they are released. Then the cars with the retainers closed will hold their brakes applied, slowing train acceleration while the reservoirs recharge for the next brake application. The train must stop at the bottom of the grade and a crewman again walk back and return the retainers to their open (direct release) position.

The retainer valves have four positions; direct release, slow release, low pressure hold, and high pressure hold. There are very few places in the U.S. today where retainers are used on a regular basis as dynamic brakes serve much the same purpose controlling the train acceleration while the air brakes recharge. Since the dynamic brakes slow down the rate of acceleration the

brakes have longer to recharge before they are needed again. Also the retarding effort of the dynamic brakes allow the engineer to use lighter air brake applications to control train speed thus the car reservoirs are not depleted as much and require less time to recharge. However if a train should happen to go into emergency due to a burst air hose or such and stops on a long steep grade you would NOT want to release the train brakes after fixing the hose. The brakes would release completely and you will have almost no air remaining in the car reservoirs to reapply the brakes. If you don't have dynamic, or it is not sufficient to slow the train, then you'd have a run away. The solution is to walk back before releasing and turn on the retainers to hold the brakes on some cars. Then release the brakes and roll down the hill with these "retained" cars controlling the acceleration while the entire train recharges.

Empty/load Sensors:

Traction between the wheels and the rail is directly proportional to the weight on the wheels. The amount of traction determines the amount of braking that can be applied without sliding the wheels. Sliding wheels develop flat spots within a few feet. Train cars have a large weight difference between the loaded condition and the empty condition. This is especially true of modern coal hoppers and grain cars. The maximum braking effort of a car must be designed so that when in emergency (when the highest brake cylinder pressure is obtained) the EMPTY car will not slide its wheels. Unfortunately this means a heavily loaded car is under-braked even in emergency. A way was needed to allow higher brake cylinder pressures on loaded cars than on empty cars. The first step was to put larger reservoirs on the cars so that the traditional 2.5 to1 ratio of reservoir volume to brake cylinder volume was greater. This will result in higher brake cylinder pressures for any given brake pipe reduction. The problem is that higher pressure will slide the wheels of an empty car. So a pressure limiting valve is attached to the brake cylinder which will vent any excessive pressure to the atmosphere thus limiting braking effort. The exhaust of this limiting valve is open to atmosphere on an empty car allowing it to vent excess pressure. On a loaded car it is closed off so it cannot vent any pressure from the brake cylinder thus taking advantage of the higher pressure which results in higher braking effort. The closing or opening of the limiting valve exhaust is controlled by a load/empty sensing arm. The pressure limiting exhaust close off valve is mounted on the car frame just above the truck frame. One end of an arm is attached to the close off valve and the other end rests on the truck frame. If the car is EMPTY the car body rides high on the springs and the arm moves the close off valve to the open position allowing the limiting valve to vent excess pressure. A LOADED car rides low on the springs and the arm is pushed up, moving the close off valve to the closed position thus preventing the limiting valve from venting the higher brake cylinder pressure.

Equalizing Reservoir:

I stated earlier that the engineer makes a service application of the brakes by moving his brake valve handle to the application position, opening a small hole, which reduces brake pipe pressure slowly. He watches the brake pipe pressure fall on the air brake gauge. When he gets the amount of reduction he desires he moves the brake handle to the LAP (blocked off) position. This method is true only for very early air brake systems. As trains got longer, thus more brake-pipe volume, it began to take too long for the air to travel thru all the cars to vent at the engineer's brake valve. His attention was fixed on the air brake gauge far too long to be safe. So the locomotives had another small reservoir installed called an EQUALIZING reservoir. This reservoir is very small compared to the brake pipe volume of a long train and thus its pressure can be

reduced almost instantaneously. The engineer's brake valve now reduces the air in the equalizing reservoir instead of the brake pipe. He can get the desired reduction (say 10 psi) very quickly and then can take his eyes off the equalizing reservoir gauge to look out ahead. An equalizing valve is connected between the equalizing reservoir and the brake pipe and it is this valve that vents the brake pipe air to atmosphere until it reduces to be equal to the equalizing reservoir pressure.

Self Lapping brake valve:

Since the late 1950s or early 1960s the engineer's brake valve has been of the self lapping type. That is he no longer has to move the brake valve back to the LAP position after making a reduction. The position of the brake valve handle determines the amount of reduction made.

One more consideration:

The engineer can change the maximum pressure of the brake pipe by adjusting the FEED VALVE at his control stand. I have used 90 psi as the standard pressure to which the brake pipe is initially charged and subsequently recharged. On the railroad I work for, 90 psi is the standard. Some railroads use 80 psi as a standard. Some mountain grade railroads use 100 psi in mountain territory on loaded coal and grain trains. What is the significance of these different pressures? During normal service braking operations there is none. A 10 psi REDUCTION from a 100 psi brake pipe, a 90 psi brake pipe, or an 80 psi brake pipe all result in 25 psi in the brake cylinder and thus equal braking effort. (remember that 2.5 to 1 ratio between service reservoir volume and brake cylinder volume.) But what happens if you make a 26 psi reduction from a 90 psi brake pipe? 90 minus 26=64 psi in the brake pipe. Remember the triple valve moves to the apply position and allows service reservoir air to flow into the brake cylinder until the service reservoir pressure lowers to equal the brake pipe pressure. As the service reservoir pressure flows into the brake cylinder the brake cylinder pressure rises. Because of the 2.5 to 1 ratio of volumes, when enough air has flowed into the brake cylinder to lower the service reservoir 26 psi the BRAKE CYLINDER PRESSURE IS 64 psi !!! (2.5 times 26 =64) This air came from the service reservoir which is NOW AT 64 psi ALSO. Since the reservoir pressure and the brake cylinder pressure ARE EQUAL no more air will flow into the brake cylinder. This condition is called a FULL SERVICE brake application because even reducing the brake pipe further, below 64 psi, WILL NOT INCREASE the amount of brake cylinder pressure. Even if you reduce the brake pipe pressure to zero psi the reservoir and brake cylinder pressure will still be 64 psi. The same as it was with only a 26 psi reduction. This full service or equalization of pressures occurs at 64 psi for a 90 psi charged system. It occurs at 71 psi for a 100 psi charged system resulting in higher full service brake effort. It occurs at 57 psi for an 80 psi charged system resulting in lower full service braking effort. The corresponding brake pipe REDUCTIONS are 26 psi for the 90 psi brake pipe, 29 psi for the 100 psi brake pipe, and 23 psi for the 80 psi brake pipe. An engineer who makes a reduction greater than these values is just wasting time, no higher braking effort results. This is all academic however since normal train operations seldom require a brake application greater than a 15 psi reduction and any reduction greater than 12 psi is considered heavy braking.

So why would mountain grade railroads use 100 psi in the brake pipe? Two reasons: First as we just saw, the full service braking effort IS higher if it is needed. Second, suppose a 10 psi reduction is made from a 100 psi charged system (100-10=90). This results in 25 psi in the brake cylinders (10 psi times 2.5). Part way down the mountain the grade lessens and train speed drops. The engineer releases the brakes and the brake pipe returns to 100 psi. The train immediately begins to accelerate down the grade. He immediately resets the air brakes by making another reduction. But the car reservoirs have only just begun to recharge so they have only 90 psi in them. If he makes a 10 psi reduction of the brake pipe (100-10=90) he will get no brakes. This is because the brake pipe will be at 90 and the reservoirs are also 90. But if he makes an additional 10 psi

reduction (a total of 20, 100-20=80psi) he will get the same braking effort as the original set, 25 psi in the cylinders. So you can see that the 100 psi charged system AFTER one 10 psi set & release is in the exact state a 90 psi charged system is in when fully charged. This means the 100 psi charged system gives him one additional 10 psi set and release before he begins to run out of air compared to the 90 psi charged system. So why not use 100 psi? There are penalties that go along with that extra pressure. One is that any weak hoses or valve gaskets may fail at the higher pressures. Another is if the train should go into emergency for any reason the higher braking effort may be enough to lock up and slide car wheels. Especially on empty or lightly loaded cars. This will cause wheel damage at the very least and possibly a derailment from failed wheels later. A third reason is it takes longer to charge a train initially to 100 psi instead of 80 or 90 and the higher pressures cause more leaks in the system.

So why the 80 psi system? Long ago, like in the 1920s, the brake pipe was 70 psi. That was fine for the 40 ton cars of the day. By the 1940s the coal cars had grown to 55 tons and the brake pipe pressure pushed to 80 psi. In the 1950s the cars were 70 tons and in the 1960s had grown to 100 tons. Still 80 psi brake pipe pressure handled the braking chores OK. By the 1970s coal & grain cars had climbed to 135 tons and the 80 psi brake pipe had little margin for error. On unit coal trains of 15,000 gross tons, even on 1.25% grades. The emergency stop distances for heavy trains was growing longer and longer. During the 1970s our railroad rules dictated an 80 psi brake pipe for all trains EXCEPT loaded unit coal and grain trains which were to use 90 psi. This shortened emergency stop distances for these heavy trains but created other problems. For instance when the trains were unloaded the pressure had to be reduced. If a coal train using a 90 psi pressure gave cars during switching operations to a freight using an 80 psi brake pipe, the "over charge" condition had to be reduced. This didn't always get done properly resulting in stuck brakes on some cars and over heated wheels. As the weight of lumber, tank, and other cars caught up to the coal and grain cars and load/empty sensors were applied the railroad simply mandated a 90 psi brake pipe for all trains. However, railroads that don't operate unit coal trains or don't have steep grades still use 80 psi since it is adequate for their type of operations. Some yard and transfer operations that operate at low speeds still use 70 psi, taking advantage of the shorter charging times.

Dynamic Brakes:

Dynamic brakes are easy. Basically you just turn the traction motors into generators and turn the electric power they produce into heat and dissipate it. Contrary to popular belief the motors are NOT put into reverse! Normally, while pulling (motoring) the traction motors are your standard DC motor. The output of the main generator is applied to the traction motor armature and fields and they "motorvate". However when you change to dynamic braking, heavy duty contacts "re-wire" the motors. The ends of the field windings are connected across the main generator output so that the main generator is applying power only to the fields. The ends of the armature are connected across iron resistance grids. As the train moves down the track, wheels turn the traction motor armature. Since the armature is turning in a magnetic field, created by the field windings powered by the main generator, the armature generates electricity. This electricity flows thru cables up to the resistance grids, the grids get hot using up the electricity. Large blower fans cool the grids to keep them from melting. It takes lots of power to turn those armatures to generate all that electricity being thrown away as heat. This power comes from the rolling train thus retarding it. Because the armatures must turn a minimum speed to generate power, you can not stop a train with dynamic brakes. You can only control its speed or slow it down. As you near 12 mph the armatures are turning slowly enough that they generate little power so braking effort drops off rapidly. At higher speeds the amount of braking is controlled by me, the hogger. I move

the dynamic brake lever and that in turn controls the output of the main generator which is supplying the traction motor field current. The stronger the fields the more power generated by the rotating armature so the more braking effort you get. Simple ain't it? Actually that is a pretty good description of how it works but in reality it is a little more complicated. Life always is isn't it? I don't really control the output of the main generator directly. My lever controls a rheostat that controls transistors that control the field of the exciter generator. The output of the exciter goes to the field of the main generator and that controls the output of the main generator, which goes into the traction motor fields so the rotating armatures can generate the electricity producing braking effort.

Wheeze! Got it?

Also various sections of the resistance grids are switched in and out of the circuit to provide different amounts of electrical load thus different braking forces. About the only part of dynamic brakes you can see are the resistance grids and their cooling blowers. On EMD locos they are along the top of the roof of the long hood about in the center of the loco. That is the "bulge" along the roof line with one or two 36" blower fans on top. Older GEs (U25, U30 era) have the dynamic brake grids mounted in the radiator cooling air intakes on the side of the hoods. You can see them if you look thru the screens. The grid cooling air is supplied by the single large radiator fan on these GEs. Newer GEs and EMDs have a boxy affair mounted high immediately behind the cab. These have their own grid cooling blower. You can tell when any loco is in dynamic braking going down hill because these blowers suck a lot of air and whine. Once in a great while a grid cooling fan will fail or a grid will short circuit. This results in the iron grids actually melting, accompanied by molten slag blowing from the unit and all sorts of arcing and pretty sparks. A great show at night.

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