Disclaimer

Thank you for making Wabtec Corporation your choice for educational material.

All our training publications are designed as teaching tools for a specific area of railway equipment instruction. As with any training literature, it will eventually become out of date. For this reason, it is important that only the current edition of this training package be used. To ensure you have the current edition please contact your Wabtec representative. Wabtec Corporation produces a line of instructional pamphlets and brochures for each of the components that Wabtec manufactures to help augment the training process. This publication is under copyright to the Wabtec Corporation. Any reproduction in whole or in part without written consent from an officer of Wabtec Corporation is strictly prohibited.

This book may contain information covering some products manufactured by companies other than Wabtec. This is done to give you, the user, an opportunity to utilize one manual for the majority of your training requirements.

Information covering products not supplied by Wabtec Corporation is provided as a general guide as to how these products should perform. Wabtec Corporation accepts no responsibility for the operation of products supplied by others, nor the information stated herein as to design or intended dimensional limits of such products.

Technical questions on the equipment shown in this booklet should be directed to the original manufacturer. If there are any discrepancies between this book and the original manufacturer standards, the original manufacturer instructions take precedence.

Wabtec Corporation accepts no responsibility for injury or damage to personnel or equipment resulting from either direct or indirect use of this manual.

For Technical Support contact your local Wabtec Corporation representative or Wabtec Training in Wilmerding, Pennsylvania, USA at 412-825-1453.

Michael Zenert

(Michael Zenert)
Manager - Air Brake Training
Wabtec Corporation

© 2001 Wabtec Corporation
Introduction

The development of the freight car control valves in use today took over 100 years. Looking at the internal ports and passages of an ABDW or ABDX valve, it is easy to understand why it took so long to develop. Inside the control valves are pistons, “O” rings, check valves, diaphragms and numerous small openings called ports and passages. All of these components must work together to make the valve function as it was designed. During the normal operation of the brake system each port, passage, valve, etc. must direct air, allow air to move, vent, or cause another reaction.

To understand the operation of each different valve, one must be able to read an air brake diagram. The first look at a control valve schematic diagram may be very intimidating. However, with some guidelines the diagrams become a little more understandable. When trying to understand air brake diagrams there are a few principles that must be kept in mind:

1. There is no green air, red air, pink air, etc. These colors are used to identify air used for a specific application.
2. Memorizing air color charts does not necessarily enable you to understand how the valve works. Different companies may use different color charts.
3. Currently, there is no electricity on a freight car. The control valve operation is pneumatic requiring air pressure to make the valve function properly. Air pressure will also open or close ports and passages depending upon the desired reaction.
4. For every action there is an equal and opposite reaction. To make the valve react, a pressuredifferential is required. This differential may be caused by a spring, air pressure or both. This pressure differential causing the piston, slide valve, etc. to move will result in other reactions. By controlling what these other actions are or directing their movement, we make the valve more efficient and operate better.

Drawings showing diagrammatic views of air brake valves, show them on one plane. This is done to easier identify and understand the overall operation of the valve. The diagrams are not intended to show the actual construction of the valve.
# Table of Contents

**PART I: Parts of an Air Brake Diagram** ................................................................. 4  
A. Piston ...................................................................................................................... 4  
B. Slide Valve ............................................................................................................. 5  
C. Graduating Valve .................................................................................................. 5  
D. Diaphragms .......................................................................................................... 6  
E. Springs ................................................................................................................... 6  
F. Chokes .................................................................................................................... 6  
G. Ports ....................................................................................................................... 6  
H. Passages ............................................................................................................... 6  
I. Chambers .............................................................................................................. 6  
J. Junctions and Crossings ....................................................................................... 6  
K. “O” Rings ............................................................................................................. 7  
L. Spool Valves ....................................................................................................... 7  
M. Check Valves and Plug Valves ........................................................................... 7  

**PART II: Pressure Differentials** ....................................................................... 8  
A. Operation of the J-1 Relay Valve ....................................................................... 9  
B. The 26-C Brake Valve Cut-Away ..................................................................... 13  

**PART III: Coloring Diagrams** ......................................................................... 15  

**PART IV: Piping Schematics and Port Diagrams** ......................................... 17  
A. Piping Schematics ............................................................................................. 17  
B. Port Diagrams .................................................................................................. 18  

**REVIEW EXERCISE** ...................................................................................... 19
PART I: PARTS OF AN AIR BRAKE DIAGRAM

The design of any air brake valve is more easily understood by recognizing some major components and parts. Note, not all valves have all the components shown and described in this booklet.

A. Piston

The piston is the heart of the control valve. The service portion has a piston, slide valve, graduated valve and a slide valve seat. Earlier style pistons used in AB Control Valves were mounted horizontally using a brass ring on the piston ring for a seal. The pistons used in ABD, ABDW and ABDX valves are mounted vertically using a rubber diaphragm as a seal. The AB Control Valve is no longer allowed in interchange service, therefore this booklet and other manuals in the series will cover only the operation of a typical ABDX piston. The ABDX piston has a definite shape. The top or head of the piston is round and has a rubber diaphragm attached. The main stem of the piston is also round but may have some flat areas in which to attach the slide and graduated valves. The shape of the piston has a direct relationship to it’s movement, it allows air to flow around the stem and allows free movement of the piston.
B. Slide Valve

Slide valves are attached to the piston inside the control valve. They move depending upon the movement of the piston but have a certain amount of slack in their movement. Slide valves have numerous holes in them to allow air to move from one area to another. The slide valve will align with the slide valve seat. The slide valve seat is flush against the slide valve to ensure a proper seal for each opening as the ports align. To determine where the slide valve ends and the slide valve seat begins, observe the crosshatching on the diagram. When the crosshatching changes the slide valve ends.

C. Graduating Valve

Graduating valves are flat valves inserted into an opening in the stem of the piston. They are also flush against the slide valve. They have small openings in them to allow passage of air. When the piston moves the graduated valve moves, this causes the ports to align on the slide valve allowing air to flow resulting in a valve reaction.
D. Diaphragms

Diaphragms are rubber separators attached to the center of the piston and the outer edge of the valve casting. This provides a positive seal on both sides of the piston resulting in the formation of a cavity on both sides of the diaphragm. Pressure exerted on one side of the diagram causes the piston to move resulting in the slide valve and graduated valve moving as well. Diaphragms are shown as solid black double “U” shaped devices.

E. Springs

Springs are used to provide a resistant force to offset the effects of an air pressure balance. They may be attached to the end of a piston or spool valve and be of various sizes. They provide a specific pressure resistance as indicated in psi. On an air brake diagram they are shown as a series of diagonal lines or a series of dots lining up diagonally.

F. Chokes

Chokes are used in the air valve to provide a resistance to the free flow of air. They provide for a build up or a slowing down of the air flow to a specific area. Chokes are shown in the air lines as a simple block with a small opening through the center.

G. Ports

Ports are openings in the valve assembly that allow air movement when they align one passage and another. Ports are shown on an air brake diagram as openings that may be colored to reflect the type of air in them. Ports will open or close depending upon the movement of the valve alignment.

H. Passages

Passages are similar to ports except they do not open or close. They are stabilized lines for the movement of air. They are openings with colored air in them.

I. Chambers

These are open areas used to hold a build up of air pressure. This build up of pressure may be used with chokes to provide a fast initial drop in pressure and slower reactionary pressure release. They may be open areas under or above the piston used to cause the piston to move. Chambers in and around the piston and slide valve will be colored the same as long as they are connected.

J. Junctions and Crossings

Air flowing through passages will occasionally move to an area where the air can flow in more than one direction. These changes in direction may cause several operations to occur simultaneously. Crossings shown on air brake drawings are drawn with no open connection between the different air lines.

September 2001
K. “O” Rings

These are rubber rings attached to the shaft of a spool valve or other similar valve. They provide a seal that prevents the passage of air beyond their point of attachment. “O” rings are round and are shown as two black dots along a horizontal plane.

L. Spool Valves

Spool valve are pistons that normally have a round shaft with lands or depressions in the shaft to attach “O” rings. The spool valves normally have a diaphragm attached to the top of the spool. Keep in mind on an air brake diagram, the spool valve will be drawn flat with a diagram. The “O” Rings will be shown as two black opposing dots.

M. Check Valves and Plug Valves

Check valves are used to stop the flow of air in one direction but will open at a specific pressure to allow the air to flow in another direction. They typically use a spring attached to provide resistance at one end and a rubber seal at the other end.
PART II: PRESSURE DIFFERENTIALS

Air brake valves are effective because of pressure differential. Having two forces exerting the same pressure from different directions on an object will not allow that object to move. However, by increasing the amount of pressure on one side we increase the force on that side causing the object to move in the opposite direction.

The same holds true with the operation of the control valve. By having air under pressure exerting force on both sides of a flexible diaphragm, the diaphragm will not move. By increasing the air pressure on one side, the diaphragm will move. As already shown, the control valve has a piston with a diaphragm. When the diaphragm moves it causes the piston to move. By attaching the slide valve and a graduating valve to the piston we have the makings of a control valve.

By using a small amount of air pressure in a small chamber we can hold open certain ports and passages to allow a larger volume of air to pass from one location to another. The only drawback now is that by having more pressure on one side, we have caused the piston to move. What will cause it to move back? By applying the same pressure, it will not move so we need more pressure or force to move it back. We have no more air but we do have a spring.

This simple philosophy is what is behind the air brake valve operation. There will always be a reaction to whatever is done within the valve. Is the reaction desirable or undesirable. If it is undesirable, how do we counteract it.

To illustrate this process we will use the J-1 Relay Valve. In this diagram you will note some of the items described previously.

"J-1" RELAY VALVE PORTION
A. Operation of the J-1 Relay Valve

Taking the information covered so far in this manual and applying it to the J-1 Relay Valve we get a better idea on how the air causes the valves inside to move and react resulting in a desired reaction. The main component inside a J-Relay Valve is the internal piston. This piston is hollow to allow for air movement. On the bottom of the piston is a diaphragm and on the top is a check valve.

This diagram shows the J-1 Relay Valve in operation when applied to a locomotive brake system. J-Relay valves may occasionally be applied to freight cars. In most cases they are used as part of the empty/load brake system but they may also be used for cars with multiple large brake cylinders. The provide for the use of a small pilot pressure to control a large volume of air directed to the brake cylinder.

For this application you will note # 6 pipe is the air pressure from the locomotive main reservoirs. On a freight car it will be supply air. This is the air supply that will be used to provide air pressure in the brake cylinders. Main reservoir air is a large volume of air under high pressure.

In the Normal Position there is air in pipe #6 but no air in any other port. Air from port #6 is cut off from the other passages by the check valve on top of the internal piston.

Pipe #30 is the delivery line. This is the line going to the brake cylinders. There is no pressure in this line at this point because there is no link to the supply line (pipe #6). However, to ensure there is no brake application, pipe #30 is connected to Exhaust (EX) or atmosphere. This connection is through the hollow stem of the piston.

Pipe #16 is our control line air. This is the pipe used to produce a brake application. At this point there is also no air pressure in this line. This line goes to a chamber at the bottom of the piston. In this chamber, the piston will move up and down depending on the pressure exerted on the diaphragm.
To provide a brake application, air pressure must be forced into line 16. This will cause a pressure build up in the chamber below the piston, causing the diaphragm to move forcing the piston upward. The top of the piston will move up to contact the check valve and cause it to unseat. This allows air to travel from the supply line past the round shaft of the piston into the brake cylinder (pipe #30). Result: a brake application.

To regulate the amount of brake application, the air directed to the brake cylinder is also allowed to flow to the passage on top of the piston and to the chamber on the top of the diaphragm of the piston. The air into this chamber is directed through a choke to allow the brake cylinder pressure to build up first. When the air pressure is the same on both sides of the diaphragm and with the use of the springs, the piston will move back down. This stops any further brake application effectively causing a Lap condition.

If there is a leak in the brake cylinder line (pipe #30) the pressure on top of the piston diaphragm will now be less than the pressure below. This will cause the piston to rise again to replace the lost air.

To get a release of the brakes, the pressure under the piston (pipe #30) is allowed to escape. With no air pressure under the piston and having pressure on top of the diaphragm, the piston will move down. This now causes the check valve to close off pipe #6, supply air and allows pipe 30, brake cylinder air to again flow to exhaust (EX).
Reading Air Brake Diagrams

The advantage of this arrangement: it only requires a small amount of control air to result in a brake application. This allows a higher volume of air pressure to supply several brake cylinders. The J-Relay can also compensate for leakage in the brake cylinder system as described.

The drawing of the “J-1 Relay Valve is an isometric (three dimensional) view diagram. This valve was chosen because it has many of the components found in brake equipment valves and is still relatively simple to understand. Note the following components:

- Cavities
- Ports and Passages
- Piston
- Diaphragm
- Check Valve
- Springs
- O-Rings
- Choke

When looking at more complicated drawings like the “ABDX” Emergency portion or the “26-C” Brake Valve there are a few other things to consider. In addition to the components illustrated on the “J-1”, these diagrams illustrate:

- Slide Valve (for the ABDX)
- “Jumpovers” or continuations of a passage where it is necessary to continue the passage behind another component
- Ring Gaskets
- Plug Chokes

With the exception of slide valves, any metal to metal joint should be considered as not air tight thus allowing air to pass by unless there is a rubber seal in the form of a gasket, (face or ring), a diaphragm or an O-ring.

Most pipe connections will bear a pipe number as well as a name. Pipe numbers are very important on diagrams where the lines cross many times, such as on the 26-C Brake Valve. They are not exclusive, it is possible that a pipe on one type of brake equipment may have the same number as a pipe on a second type of brake equipment but have a different function. Also, since a pipe may branch within or outside a valve component, the continuation of a pipe may bear a different number than its source. Similarly, the names of pipes are generally accurate as a description of their function but this may not always be the case. For example, with “J” type relay valves, the EX (exhaust) port is frequently used to provide a pressure pilot signal to one of the diaphragms. Therefore, use pipe numbers and names as a general guide only, not as an infallible description of all of their functions.

On the next page is a diagram of an ABDX Emergency Portion and Pipe Bracket. Try to recognize some of the items described in the previous pages of this workbook. Some of the items have been identified, some have not. Notice the pipes coming from the Pipe Bracket are identified.
Reading Air Brake Diagrams

ABDX Emergency Portion
Service Lap Position
B. The 26-C Brake Valve Cut-Away

On the following page is a cut-away of the 26-C Brake Valve. You will notice the diagram has gotten progressively more complicated. This is because the valve is more complicated with a lot more functions happening simultaneously. To help understand the overall operation of this valve several things have been added to the diagram:

1. The pipes have been numbered
2. A legend has been added to the top of the page.
3. Port diagrams for the individual valve functions have been added.
4. Valves within the valve have been identified.

This diagram can be used to simulate multiple functions. These multiple functions are because of the different valves within the valve. Their operation is only understood with text (not shown in this workbook) and the port diagrams which are shown here. The port diagrams show air movement connections between numbered pipes depending upon the position of the brake valve handle. The complete operation of the 26-C is described in other publications produced by Wabtec.

In this diagram you can see many of the items listed earlier in this book. In most cases you will see there are multiple spool valves, “O” rings, gaskets, check valves, etc. All of these items must function in the overall operation of the valve.
Reading Air Brake Diagrams

LEGEND
Port Designation
1 Brake Pipe
21 Safety Control Pipe
3 Switch Pipe
13 Actuating Pipe
12 Emergency Switch Pipe
30 Main Reservoir Pipe
53 B.P. Cut-off Pipe
5 Equal. Res. Control Pipe
15 Equal. Res. Charging Pipe
26 Suppression Pipe
8 Lock-over Pipe
20 Ind. Application & Rel. Pipe

26-C BRAKE VALVE
PART III: COLORING DIAGRAMS

Wabtec uses a standard color scheme when designing air flow diagrams. Any color may be used, but to ensure comprehension at a later date, the same scheme should be followed for all diagrams. The "standard" color scheme will also help other people to follow the logic of the diagram without too much readjustment. The use of color on diagrams makes following the flow of air easier. Each color represents specific where the air is from or where it is being directed. For example air colored red on a locomotive air brake diagram is generally main reservoir air.

By convention, when a flow of air changes its function, it changes its color. Usually a function change will occur across a check valve or as the air passes through a choke or through a port. For example, auxiliary reservoir air in an "AB" type valve becomes brake cylinder air when the brakes are applied. In this instance, auxiliary air (yellow) passes through the slide valve where it changes to pink. It is now brake cylinder air.

On the following page is the Wabtec Color chart for Locomotive, Freight and Passenger brake equipment.
# Wabtec Air Brake Coloring Guide

<table>
<thead>
<tr>
<th>COLOR</th>
<th>26-L LOCOMOTIVE</th>
<th>AB FREIGHT</th>
<th>PASSENGER</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>Main Reservoir</td>
<td>Emergency Reservoir</td>
<td>Emergency Reservoir</td>
</tr>
<tr>
<td>ORANGE</td>
<td>Brake Pipe</td>
<td>Brake Pipe</td>
<td>Brake Pipe</td>
</tr>
<tr>
<td>YELLOW</td>
<td>Auxiliary Reservoir</td>
<td>Auxiliary Reservoir</td>
<td>Auxiliary Reservoir</td>
</tr>
<tr>
<td>PINK</td>
<td>Brake Cylinder</td>
<td>Brake Cylinder</td>
<td>Brake Cylinder</td>
</tr>
<tr>
<td>DARK BLUE</td>
<td>N/A</td>
<td>Quick Action</td>
<td>Quick Action</td>
</tr>
<tr>
<td>LIGHT BLUE</td>
<td>Independent Application</td>
<td>N/A</td>
<td>Signal Pipe</td>
</tr>
<tr>
<td>LIGHT GREEN</td>
<td>Control Reservoir</td>
<td>N/A</td>
<td>Service Reservoir</td>
</tr>
<tr>
<td>DARK GREEN</td>
<td>Equalizing Reservoir</td>
<td>Supply Reservoir</td>
<td>Supply/Control Reservoir</td>
</tr>
<tr>
<td>PURPLE</td>
<td>Relay Valve Delivery</td>
<td>Relay Valve Delivery</td>
<td>Relay Valve Delivery</td>
</tr>
<tr>
<td>BROWN</td>
<td>Selector Volume</td>
<td>N/A</td>
<td>Straight Air Pipe</td>
</tr>
</tbody>
</table>
PART IV: PIPING SCHEMATICS AND PORT DIAGRAMS

A. Piping Schematics

Piping Schematics are simple, single line drawings that show the interconnection of brake equipment components and identify the pipes and ports. Generally the various valves are shown merely as box outlines, although in some cases a little “window dressing” may be added. In order to keep the diagrams simple, connections within the valves are not shown. For this purpose, port diagrams are necessary.

Piping schematics are extremely useful in tracing air flow through the brake equipment. Different piping schematics are drawn, depending on the operation of the valve. For instance, brake pipe charging the car control valve is different than making a brake application. The air moves in different directions for each operation. To follow the air movement, choose the diagram which best depicts the operations you are trying to follow.

The example below shows the air flow for a locomotive automatic brake application. To make a brake application, air is reduced out of pipe 1 at the 26-C Brake Valve. This air is directed to exhaust (EX). The resultant drop in brake pipe causes air from the auxiliary reservoir to be directed through pipe 5 on the 26-F to pipe 16 to the J-1 Relay Valve. The J-1 Relay will move to allow main reservoir air, pipe 6 to flow to pipe 30 to the brake cylinder.
B. Port Diagrams

Schematic diagrams of valves, showing the internal arrangement of components and the ports and passages are usually drawn with the valve in the “at rest” position, with no air under pressure anywhere in the valve. This is usually the “Release” position of the valve. Unfortunately, the schematics, may not show clearly which ports and passages are connected. Once the valve moves to the “Apply” position, then the picture becomes even more unclear. Some valves may pass through several stages of operation, in which case it is almost impossible to trace air flow.

For most valves it is possible to construct “Port Diagrams” which show the inner connections of ports and passages within the valve at certain operating positions of the valve. For valves which take a position and then hold it, this is a good and simple approach. An example of this would be the J-1 Relay Valve, where it is possible to show the various port connections for its positions of Release, Apply and Lap. For valves with several spool valves that pass through a series of events before achieving a point of rest or stability, the construction of a port diagram is almost impossible. An example of this would be the 26-F Control Valve.

A Port Diagram consists of a “matrix” of intersecting lines – conventionally the vertical lines are the various valve positions, the horizontal lines represent the ports or pipes. By encompassing the line intersections we identify the ports connections for the individual valve application. If the port remains open the block will continue across several positions and may encompass several other ports or passages.

The diagram below illustrates the MU-2-A Valve. The diagrammatic shows the valve in the “Lead or Dead” position. In this position, it is relatively easy to see the port connections. It is not so easy to visualize the connections that are made when the valve is moved to either of the two “Trail” positions. To move the valve into the Trail positions the brass knob must be pushed in and turned. This causes the spool valve inside to move to the right. By moving the spool valve the passages will change because the O-rings will change alignment. Line up the Port Diagram to the movement of the spool valve to see the connections of the passages within the valve.

MU-2-A Selector Valve
1. From the diagram shown below, identify each of the parts indicated with an arrow.

1. _________________________  5. _________________________  
2. ___________________________  6. _________________________  
3. ___________________________  7. _________________________  
4. ___________________________  8. _________________________
2. Construct a port diagram for an H-5 RELAYAIR Valve. A diagrammatic of the valve is shown, with the outline of the Port Diagram. The sequence of operation for the valve is:

**Release Position**
- Port 10: Control, Blanked
- Port 9: Exhaust, Open
- Port 11: Delivery, Open
- Port 12: Supply, Blanked

**Applied Position**
- Port 10: Control, Open (Pressure being supplied)
- Port 9: Exhaust, Blanked
- Port 11: Delivery, Open
- Port 12: Supply, Open

**LEGEND**
- 10 Control
- 9 Exhaust or Supply
- 12 Supply or Exhaust
- 11 Delivery
ANSWERS
Reading Air Brake Diagrams Exercise

1. From the diagram shown below, identify each of the parts indicated with an arrow.

1. DIAPHRAGM
2. PISTON
3. SLIDE VALVE
4. CHECK VALVE
5. SPOOL VALVE
6. O RING
7. PASSAGE
8. CHOKE
ANSWERS

2. Construct a port diagram for an H-5 RELAYAIR Valve. A diagrammatic of the valve is shown, with the outline of the Port Diagram. The sequence of operation for the valve is:

**Release Position**
- Port 10: Control Blanked
- Port 9: Exhaust Open
- Port 11: Delivery Open
- Port 12: Supply Blanked

**Applied Position**
- Port 10: Control Open (Pressure being supplied)
- Port 9: Exhaust Blanked
- Port 11: Delivery Open
- Port 12: Supply Open

---

**H-5 RELAYAIR VALVE**

**RELEASED**

**APPLIED**

**LEGEND**
- 10 Control
- 9 Exhaust or Supply
- 12 Supply or Exhaust
- 11 Delivery