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Pneumatic Piping for Vehicles

Abstract: This document establishes a standard for designing and arranging air brake and auxiliary pneumatic piping on passenger vehicles.

Keywords: air brake, auxiliary, carbon steel pipe, copper tubing pipe, stainless steel pipe, stainless steel tubing

Summary: This standard provides a means by which passenger car pneumatic piping can be designed, installed and tested. It outlines the fundamental design characteristics for pneumatic piping for both air brake and auxiliary systems.

Scope and purpose: This standard applies to all railroads or public authorities, such as state agencies, that operate intercity or commuter passenger train service on the general railroad system. The purpose of the standard is to provide design, installation and testing requirements for air brake and auxiliary pneumatic piping on passenger cars.

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Introduction

This introduction is not part of APTA PR-M-S-029-21, "Pneumatic Piping for Vehicles."

This standard applies to all of the following:

- railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
- railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to any of the following:

- rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
- tourist, scenic, historic or excursion operations, whether on or off the general railroad system of transportation;
- operation of private cars, including business/office cars and circus trains; or
- railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Pneumatic Piping for Vehicles

1. General

This standard pertains to pneumatic piping for passenger vehicles. The following sections will refer to different types of piping and tubing material to be used on passenger vehicles.

All pipe sizes are shown in their nominal pipe size (NPS). Copper tubing is shown as its nominal/standard size, while stainless steel tubing is shown as the outside diameter (O.D.) of the tube. Metric sizes are allowed. The brake pipe (BP) trainline, main reservoir (MR) trainline and brake cylinder (BC) truck piping have required sizes. These sizes are shown as NPS, with the metric equivalent size shown in parentheses in millimeters (mm) where applicable.

2. End-of-car arrangements

The end-of-car piping is recommended to be in accordance with APTA PR-M-RP-001-97, latest revision, "End-of-Car Connections with Tightlock and Interlocking Knuckle-Type Couplers" (formerly "Air Connections, Location and Configuration of, for Passenger Cars Equipped with AAR Long Shank Tight Lock or Similar Long Shank Type Couplers").

3. Brake pipe

> **IMPORTANT:** For brake systems other than 26L, 26C and MC30 types including their electronic equivalents or utilize the brake pipe for rescue operations, the brake pipe size used shall be in accordance with the manufacturer's recommendation and approved by the authority having jurisdiction.
>
> **IMPORTANT:** No filters/filter elements shall be used in the brake pipe trainline and the brake pipe branch pipe to any valves that would restrict the emergency brake exhaust or emergency brake propagation.

3.1 Brake pipe trainline

The BP trainline shall be either 1¼ in. carbon steel pipe or stainless steel pipe, schedule 80. Stainless steel tubing for the BP trainline is allowed only when it is shielded from debris strikes. The O.D. of the stainless steel tubing shall be 1.65 in. (42 mm) with a minimum wall thickness of 0.08 in. (2 mm). The BP trainline that is outboard of the truck shall be either carbon steel pipe or stainless steel pipe, schedule 80. Stainless steel tubing may be used only with the approval of the authority having jurisdiction.

The BP trainlines shall be in accordance with Association of American Railroads (AAR) S-400. The equivalent length of the BP shall not exceed 125 ft. Exceptions to the equivalent lengths requirement shall be confirmed by the brake manufacturer. The number of control devices and accelerated service devices shall be in accordance with AAR S-401.

3.2 Brake pipe branch piping

All BP branch lines under frame shall be either 1 in. carbon steel pipe or stainless steel pipe, schedule 80. Stainless steel tubing for the BP branch piping is allowed only when it is shielded from debris strikes.

The BP branch lines containing main control devices, vent valves and accelerated service devices shall meet the equivalent length requirements per AAR S-400. Exceptions to the equivalent length requirements shall be confirmed by the brake manufacturer.

3.3 Brake pipe attachments

All main control valves, emergency vent valves and accelerated service features shall be taken from the top of the BP. These devices shall not be located at a low point in the BP trainline, in order to prevent the introduction of water into the devices. The branch tees interfacing with these devices shall either be an industry standard BP branch pipe tee or shall be a standard tee angled 30 deg. upward at a minimum. Examples of industry standard BP branch pipe tees are shown in AAR S-400. Industry standard BP branch tees shall be installed in accordance with AAR S-400.

3.4 Brake pipe exhaust

The BP exhaust lines shall be piped outside the car with a vent protector at the end of the pipe. There shall be a minimum clearance between the end of the vent protector as shown in AAR S-400. The BP exhaust lines shall not be in areas where wheel splash can occur. The exhaust lines shall be either piped straight down or have a downward angle.

The BP exhaust lines' materials and sizes shall comply with the requirements of sections 5 and 6 of this document.

4. Other brake-related piping

IMPORTANT: For brake systems other than 26L, 26C and MC30 types including their electronic equivalents or utilize the main reservoir (MR) pipe for rescue operations, the main reservoir pipe size used shall be in accordance with the manufacturer's recommendation and approved by the authority having jurisdiction.

4.1 Main reservoir pipe trainline

The MR pipe trainline shall be 1 in. carbon steel pipe or stainless steel pipe, schedule 80. Stainless steel tubing for the MR trainline is allowed only when it is shielded from debris strikes. The O.D. of the stainless steel tubing shall be 1.38 in. (35 mm) with a minimum wall thickness of 0.08 in. (2 mm). The MR trainline that is outboard of the truck shall be either carbon steel pipe or stainless steel pipe, schedule 80. Stainless steel tubing may be used only with the approval of the authority having jurisdiction. The MR trainline shall comply with the requirements of sections 5 and 6 of this document.

4.2 Main reservoir branch piping

All MR branch lines under frame shall be either carbon steel pipe or stainless steel pipe, schedule 80. Other MR branch lines that continue inside the car shall comply with the requirements of sections 5 and 6 of this document.

4.3 Brake cylinder piping

4.3.1 Car

Under-frame BC lines that are not on the truck shall be either carbon steel pipe or stainless steel pipe, schedule 80. Stainless steel tubing for the BC lines is allowed only when it is shielded from debris strikes.

Other BC lines that are located inside the car shall comply with the requirements of sections 5 and 6 of this document.

4.3.2 Truck

BC lines on the trucks shall be either minimum ½ in. carbon steel pipe or stainless steel pipe, schedule 80. Truck piping shall be snug to the truck frame and shielded from direct wheel splash. Stainless steel tubing is allowed when it is shielded. The O.D. of the stainless steel tubing shall be 0.59 in. (15 mm) with a minimum wall thickness of 0.06 in. (1.5 mm). BC lines shall be configured to avoid low points or other geometry where moisture could collect.

It is recommended that the final connection to the brake actuators/units shall be made with hose connections for ease of maintenance.

4.4 Leveling system and parking brake control piping

Pipe diameter and bend radius shall conform to the system supplier's recommendations.

4.4.1 Car

Under-frame lines that are not on the truck shall be either carbon steel pipe or stainless steel pipe, both schedule 80. Stainless steel tubing is allowed only when it is shielded from debris strikes.

Other lines that are located inside the car shall comply with the requirements of sections 5 and 6 of this document.

4.4.2 Truck

Truck piping shall be either carbon steel or stainless steel pipe, both schedule 80. Piping shall be located to avoid debris strikes and direct wheel splash. Piping shall be configured to avoid low points or other geometry where moisture could collect. Stainless steel tubing is allowed only when it is shielded from debris strikes.

4.5 Miscellaneous

Pipe diameter and bend radius shall conform to the system supplier's recommendations.

4.5.1 Car

All lines within the carbody or under-frame lines that are not on the truck shall comply with the requirements of sections 5 and 6 of this document.

Air brake gauge lines shall be ¼ inch internal diameter minimum.

4.5.2 Truck

Truck piping shall be either carbon steel or stainless steel pipe. Piping shall be located to avoid debris strikes and direct wheel splash. Piping shall be configured to avoid low points or other geometry where moisture could collect. Stainless steel tubing is allowed only when it is shielded from debris strikes.

5. Bend radius

5.1 Air brake piping and tubing bend radii

Pneumatic air brake lines using carbon steel pipe, stainless steel pipe and copper tubing shall be in accordance with AAR S-401 minimum recommended radius bend. It is recommended for air brake using stainless steel tubing to be in accordance with the preferred bend radii in Deutsches Institut für Normung (DIN) 25570 as shown in **Table 1**. Bends shall be smooth and shall not bunch.

TABLE 1
Preferred Bend Radii from DIN 25570

Tube Size mm (in.)	Preferred Bend Radius mm (in.)
42 (1.65)	110 (4.33)
35 (1.38)	100 (3.94)
28 (1.1)	80 (3.15)
22 (0.87)	65 (2.56)
18 (0.71)	45 (1.77)
15 (0.59)	40 (1.58)
10 (0.39)	25 (0.98)
6 (0.24)	25 (0.98)

5.2 Auxiliary piping and tubing bend radii

Pipe and tubing used for other auxiliaries that are not part of the air brake lines may have bend radii less than AAR S-401. These other non–air brake line bends shall also be smooth and not bunch. For stainless steel tubing for auxiliary lines, it is recommended to use the preferred bend radii in DIN 25570, as shown in **Table 1**.

5.3 Other bend radii

Hose bend radii shall conform to the recommendation bend from the hose manufacturers, along with other radii restrictions. AAR M-618 hoses shall follow the minimum bend radius specified in AAR M-618. Hoses shall be free of kinks.

6. Pneumatic piping and tubing materials

6.1 Size selection

6.1.1 Pipe and tube size selection, imperial

Pipes shall be identified by the NPS according to ASTM A53 and ASME B36.19 for carbon steel pipe and stainless steel pipe, respectively. Material shall conform to ASTM A312.

Copper (Type K and L) tubing shall be identified by the nominal/standard size in accordance with ASTM B88, while stainless steel tubing shall be identified by the O.D. of the tube. **Table 2** provides the equivalent inner diameter (I.D.) for Copper Type K and stainless steel tubing. **Table 3** provides the equivalent I.D. for copper Type L and stainless steel tubing.

TABLE 2
Copper Type K and Stainless Steel Tubing Equivalent Sizes

Copper	Nominal/Standard	¼ in.	⅜ in.	½ in.	¾ in.	1 in.
Stainless Steel	O.D.	⅜ in.	½ in.	⅝ in.	⅞ in.	1⅛ in.
Wall Thickness		0.035 in.	0.049 in.	0.049 in.	0.065 in.	0.065 in.
I.D.		0.305 in.	0.402 in.	0.527 in.	0.745 in.	0.995 in.

TABLE 3
Copper Type L and Stainless Steel Tubing Equivalent Sizes

Copper	Nominal/Standard	¼ in.	⅜ in.	½ in.	¾ in.	1 in.
Stainless Steel	O.D.	¼ in.	⅜ in.	½ in.	¾ in.	1 in.
Wall Thickness (Stainless Steel Wall Thickness)		0.030 in. (0.028 in.)	0.035 in. (0.035 in.)	0.040 in. (0.035 in.)	0.045 in. (0.049 in.)	0.050 in. (0.049 in.)
I.D. (Stainless Steel I.D.)		0.19 in. (0.194 in.)	0.305 in. (0.305 in.)	0.42 in. (0.43 in.)	0.66 in. (0.652 in.)	0.90 in. (0.902 in.)

6.1.2 Pipe and tube size selection, metric

Pipes shall be identified by NPS according to ASTM A53M and ASME B36.19M and for carbon steel pipe and stainless steel pipe, respectively. Material shall conform to ASTM A312M.

Tubes shall be identified by the O.D. of the tube. The recommended sizes for tubing are shown in **Table 4**, along with the equivalent imperial size in parentheses.

TABLE 4
Tubing Metric Sizes

O.D. mm (in.)	Wall Thickness mm (in.)
42 (1.65)	2 (0.08)
35 (1.38)	2 (0.08)
28 (1.1 in)	1.5 (0.06)
22 (0.87)	1.5 (0.06)
18 (0.71)	1.5 (0.06)
15 (0.59)	1.5 (0.06)
10 (0.39)	1.5 (0.06)
6 (0.24)	1 (0.04)

6.1.3 Plastic tubing size selection

Plastic tubing shall be identified by the O.D. of the tube.

6.2 Copper tubing

Copper tubing, if used for air brake lines, shall be Type K (and A). Copper tubing Type K (and A) or Type L (and B), shall be used only in other auxiliary applications. Both Copper Type K and L (A and B) tubing shall be in accordance with ASTM B88/88M. Copper tubing used under floor shall be shielded from debris strikes.

6.3 Plastic tube

Plastic tubing lines shall comply with Society of Automobile Engineers (SAE) J844 Type 3B. Plastic tubing shall be used only inside the car or within equipment enclosures. All plastic tubing must meet flame, smoke and toxicity requirements of 49 CFR 238. Plastic tubing shall be appropriately rated to the temperature environment to which it is exposed.

6.4 Hoses

End-of-car hoses shall be in accordance with AAR M-601. All other undercar hoses shall be in accordance with AAR M-618. All air brake hoses must be manufactured by an AAR-approved M-601 and M-618 supplier. All interior hoses shall meet flame, smoke, and toxicity requirements of 49 CFR 238.

BP hoses shall be -24 size, either M-601 or M-618. MR hoses shall be -20 size, M-618 hose.

6.5 Piping sealant

Piping and tubing seal shall be an approved liquid pipe thread sealant (TFE). The use of Teflon tape is prohibited on pipe and tube threads.

7. Other auxiliaries

The following auxiliary devices and systems shall not be supplied directly from the BP; this list is not inclusive:

- air suspension seats
- horn system
- pantographs
- pneumatically operated bells
- pneumatically operated doors
- sanding system
- toilets
- water raising system
- windshield wipers

7.1 Water raising system

Water raising valves shall be located above the water tank. Water raising systems shall have their own potable water supply. Water raising systems shall also include a governor valve, choke, check valve and vented cutout cock between the water raising tank and the MR trainline.

7.2 Toilets

Toilets, if supplied air, shall be supplied by the MR trainline. Toilet lines shall include a governor valve, choke, check valve and vented cutout cock.

7.3 Pneumatically operated doors

Pneumatically operated doors shall have their own reservoir.

8. Fitting restrictions

Pipe fittings shall be sized to U.S. National Pipe Thread (NPT) and in accordance with ASME B1.20.1. Metric pipe fittings are allowed and shall be in accordance with the International Organization for Standardization (ISO) 261.

Fittings shall be kept to a minimum in the BP trainline. The use of 90 deg. elbow fittings is prohibited in BP per AAR S-400.

When determining the equivalent length of the pipe, the fitting shall be considered.

8.1 Steel fittings

All stainless steel tubing fittings shall be in accordance with either SAE J514 or DIN ISO 8434-1.

Where flanges are required for use, flanges shall follow ASME B16.1 for carbon steel pipe and ASME B16.5 for stainless steel pipe.

BP and MR pipe shall utilize schedule 80 or equivalent.

8.2 Copper fittings

Wrought copper and copper alloy solder fittings shall be in accordance with either ASME B16.22 or ASME 16.29. Flange and flanged fittings shall be in accordance with ASME B16.24. Cast bronze threaded fittings shall be in accordance with ASME B16.15.

8.3 Plastic tube fittings

Plastic tubing shall use fittings in accordance with SAE standards. The use of bite-type fittings is allowed with plastic tubing with approval of the authority having jurisdiction

9. Valve protection and cutout cock arrangements

9.1 Valve protection

9.1.1 Conductor valves

Conductor valve (passenger emergency valve) handles located in the passenger compartment or vestibule should be located and protected by a guard, recessed or other means that allows ready access, but prevents accidental activation as a result of being struck or accidentally grabbed by a person attempting to stabilize themselves. Conductor valves located in the cab must not be protected.

9.1.2 Valves exposed

Valves that are exposed to possible debris strikes shall have a guard or otherwise be protected from debris strikes. The exhaust of valves shall be protected from wheel spray, dirt, debris strike and damage. There shall be a minimum of 5 in. of clearance between the end of the vent protector on the valve and its surrounding area.

9.1.3 Reservoirs and drain valves

Reservoir or other drain valves shall have a guard or otherwise be protected from debris strikes.

9.2 Cutout cock arrangements

9.2.1 Vented cutout cocks

Vented cutout cocks shall be placed in an orientation that allows for proper venting per manufacturer recommendation.

9.2.2 Valve handle clearance

To avoid pinch points on the valve handle for the operator's hand, there shall be at minimum 2.5 in. of clearance between the valve handle and surrounding equipment throughout the full range of handle movement.

9.3 Cutout cocks with locking handles

9.3.1 Performance of locking function

Positive locking function shall be provided for piping cutout cocks located underfloor.

10. Securement

Piping and tubing shall be rigidly mounted based on the vibration, shock and other environmental constraints based on location such as interior, exterior and truck locations.

Piping and tubing passing through the flooring must include the appropriate fire protection to avoid flame and smoke entry to the passenger/operator cab.

If pipe/tube passes through holes in floors, bulkheads, structure or any fixed member, it shall be rigidly protected against possible damage or noise due to bearing, abrasion or rattling induced by car dynamics.

For pipe/tube clamps, isolation material must be considered. The material shall be nonreactive, such as elastomeric or plastic.

11. Welding, brazing and soldering

11.1 Steel

Shielded metal arc welding (SMAW) or flux-cored arc welding (FCAW) processes are recommended. Minimum tensile strength of 70,000 psi is recommended for filler material. Fittings that are not threaded must be a socket weld type that is gapped within the socket to prevent cracking from the weld shrinking as it cools. Gapping rings are acceptable for use.

11.2 Stainless steel

SMAW, FCAW, GMAW, and gas tungsten arc welding (GTAW) processes are recommended. Filler material shall match the base material as closely as possible. Oxidation forms within stainless piping during the welding process. Back purging using 100 percent argon is recommended during the welding process. Fittings that are not threaded should be a socket weld type gapped within the socket to prevent cracking from the weld shrinking as it cools. Gapping rings are acceptable for use. Stainless is more prone to cracking during the cooling period; therefore, special attention is needed if this material is used.

11.3 Brazing and soldering

Copper tubing shall be brazed or soldered while using inert gas.

Brazing shall conform to AWS B2.2/B2.2M.

Soldering shall conform to AWS B2.3/B2.3M.

11.4 Cleaning

The pipes and tubes shall be cleaned after assembly to remove any residue or contaminants.

11.5 American Welding Society D15.1

American Welding Society (AWS) D15.1 shall be used for welder qualifications, testing of samples, nondestructive testing of welds and visual inspection criteria.

12. Reservoirs

All reservoirs shall be designed, manufactured and tested to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, latest revision. Telltale holes, per 49 CFR 229.31, shall be applied to the main reservoirs and brake cylinder supply reservoirs. ASME certifications shall be provided for those reservoirs per the ASME Boiler and Pressure Vessel Code.

13. Testing

The AAR S-471 BP Restriction Test shall be completed for newly constructed vehicles and when major rework is done to the BP.

All vehicle piping and tubing shall be inspected and tested to the requirements in ASME B31.1.

14. Approval

For all new vehicles or remanufactured vehicles with piping changes, the brake system piping configuration, material selection and fitting selection shall be formally approved by the brake equipment supplier.

Related APTA standard

APTA PR-M-RP-001-97, "End-of-Car Connections with Tightlock and Interlocking Knuckle-Type Couplers," (formerly "Air Connections, Location and Configuration of, for Passenger Cars Equipped with AAR Long Shank Tight Lock or Similar Long Shank Type Couplers")

References

All references and the inclusions are the current revisions.

American Society of Mechanical Engineers standards:
- ASME A53/A53M, "Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless"
- ASME B1.20.1, "Pipe Threads, General Purpose, Inch"
- ASME B16.1, "Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250"
- ASME B16.5, "Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard"
- ASME B16.15, "Cast Copper Alloy Threaded Fittings: Classes 125 and 250"
- ASME B16.22, "Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings"
- ASME B16.24, "Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500"
- ASME B16.29, "Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings--DWV"
- ASME B31.1, "Power Piping"
- ASME B36.19/B36.19M, "Stainless Steel Pipe"

Association of American Railroads standards:
- AAR MSRP M-601, "Hose, Wrapped, Air – Brake, "End Hose""
- AAR MSRP M-618, "Hose, Air, Wire-Reinforced"
- AAR MSRP S-400, "Brake Equipment – Installation Specifications"
- AAR MSRP S-401, "Brake Design Requirements"
- AAR MSRP S-471, "Brake Pipe Restriction Test"

ASTM International standards
- ASTM A312/312M, "Standard Specification for Seamless, Welded and Heavily Cold Worked Austenitic Stainless Steel Pipes
- ASTM B88/B88M, "Standard Specification for Seamless Copper Water Tube"

American Welding Society standards
- AWS B2.2/B2.2M, "Specification for Brazing Procedure and Performance Qualification"
- AWS B2.3/B2.3M, "Specification for Soldering Procedure and Performance Qualification"
- AWS D15.1, "Railroad Welding Specification for Cars and Locomotives"

Code of Federal Regulations:
- 49 CFR 229.31, "Railroad Locomotive Safety Standards" Section 31 "Main reservoir tests"
- 49 CFR 238, "Passenger Equipment Safety Standards"

DIN 25570, "Semi-finished Products for Rail Vehicles – Pipes Overview, Selection, Application, Bending Radii"

International Organization for Standardization standards:
ISO 261, “Specification for ISO metric screw threads”
ISO 8434, “Metallic tube connections for fluid power and general use”

SAE J514, “Hydraulic Tube Fittings”

Definitions

pipe: Used to distinguish from tube. Shown as NPS and schedule 40 or 80.

shielded from debris strikes: A method to protect the pipe/tube from impact damage such as utilizing underfloor equipment, car structure or protective shields as approved by the authority.

trainline: Refers to the two main air supply piping lines, BP and MR pipe.

tube: Used to transport fluid/air and expressed by the O.D. and by wall thickness

Abbreviations and acronyms

AAR	Association of American Railroads
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials International
AWS	American Welding Society
BP	brake pipe
BC	brake cylinder
CFR	Code of Federal Regulations
DIN	Deutsches Institut für Normung (German Institute for Standardization)
FCAW	flux-cored arc welding
FMVSS	Federal Motor Vehicle Safety Standards
GMAW	gas metal arc welding
GTAW	gas tungsten arc welding
I.D.	inner diameter
ISO	International Organization for Standardization
MR	main reservoir
MSRP	Manual of Standards and Recommended Practices
NATSA	North American Transportation Services Association
NPS	nominal pipe size
O.D.	outer diameter
SAE	Society of Automotive Engineers
SMAW	shielded metal arc welding
TFE	tetrafluoroethylene
USDOT	United States Department of Transportation

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