



**PDHonline Course G489 (2 PDH)**

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**Motor Vehicle Accident Reconstruction  
Special Topic 2 - Brake Failures**

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# Discussion Areas

- Understanding the Importance of Brake Failures as a Potential Cause of Motor Vehicle Accidents.
- Basics of Passenger Car Brake Systems
- Basics of Commercial Truck and Trailer Brake Systems
- Anti-lock Braking
- Traction Control and Braking
- Introduction to Brake System Failure Analysis

# NHTSA FAR Database

- The National Highway Traffic Safety Administration (NHTSA) keeps a database of traffic fatalities called the Fatal Accident Reporting System (FARS).
- The database can be found at [www.nhtsa.gov/FARS](http://www.nhtsa.gov/FARS). Take some time to investigate the website and the publicly available information that it holds.
- The database goes back to 1975, and the information recorded by NHTSA has changed over time.
- The FARS database contains data inputted by police or other traffic governing and/or investigating entities (i.e. sheriff's departments) detailing the factors behind traffic fatalities on U.S. roads.
- The FARS database may be queried by year and vehicle related Factors.

# Query of FARS database

- A query of the FARS database in 2008 had some revealing information.
- Subsequent queries haven't greatly changed the general information gleaned in 2008.

STATE: AllYEAR: 2008COUNT: Number of Vehicles/Drivers

OUTPUT OPTIONS:

**Report:**

[Vehicle Related Factors\(1\)](#)

State	None	Tires	Brake System	Tie Rod, Kingpin, Ball Joint, Etc.	Steering System - Shock	Suspension - Springs, MacPherson Strut, Axle Bearing, Control Arms, Etc.	Power Train/Engine	Exhaust System	Headlight	Signal Light	Other Light	Horn	Wipers	Seam And Control	Door Hood	Trailer Hitch	Wheel	Air Bag	Other Vehicle Defects	Safety Belt	Hit-and-Run Vehicle	Registration For Handicapped	Vehicle Being Pushed By Non-Motorist	Reconstructed/Altered Vehicle
Alabama	1,202	27	3	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	24	0	0	0	
Alaska	85	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	
Arizona	1,111	33	1	0	3	2	0	0	0	0	0	0	0	0	0	0	2	1	69	26	0	1	0	
Arkansas	755	6	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	15	0	0	0	
California	4,345	62	13	0	3	4	0	3	0	0	0	0	0	0	0	1	1	0	2	278	21	1	2	
Colorado	681	3	2	0	0	1	0	0	0	3	0	0	0	0	0	1	0	0	0	21	0	0	1	
Connecticut	341	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	15	0	0	0	
Delaware	142	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	9	0	0	0	
District of Columbia	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	
Florida	3,997	33	1	0	2	1	0	2	0	0	0	0	0	0	2	0	2	0	181	0	0	1	0	
Georgia	1,907	36	2	1	0	2	0	2	0	0	0	0	1	0	0	1	0	2	1	45	61	0	0	
Hawaii	129	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	1	0	
Idaho	297	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	
Illinois	1,317	4	2	0	0	0	0	0	0	1	0	1	0	0	0	0	0	3	0	54	0	0	0	
Indiana	1,059	7	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	24	19	0	0	
Iowa	559	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	
Kansas	480	2	1	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	10	0	1	0	

# FARS Results:

## Top Vehicle Related Factors-2008

- Out of 47338 Reports

-Tires (492)

-Brake System (119)

-Steering System (20)

-Hit and Run Vehicle (1586)

-Vehicle Registration for Handicap (176)

-Other Vehicle Defects (39)

-Headlights (22)

-Other Working Veh (Not Constr., Police, Fire, EMT) (21)

-Unknown (473)



## Other Factors:

- Airbags (5)
- Reconstructed/Altered Vehicles (17)
- Construction Vehicles (9)
- Police, Fire, EMT (15)



## Conclusions from FARS Query

- Other than factors not related to motor vehicle components, the FARS database showed that Brake failure was a the top vehicle component identified as a factor in motor vehicle fatalities.

# Passenger Car Braking Systems

- Two most common types: Caliper Brakes and Drum Brakes
- Employs a hydraulic fluid system to transmit pedal input to engage brakes.
- Direct pedal input hydraulic systems now being replaced by electronic pedal and electronic brake control systems.
- Designed for:
  - Effective Stopping Distance
  - Handling
  - Vehicle Stability
  - Usable Service Life



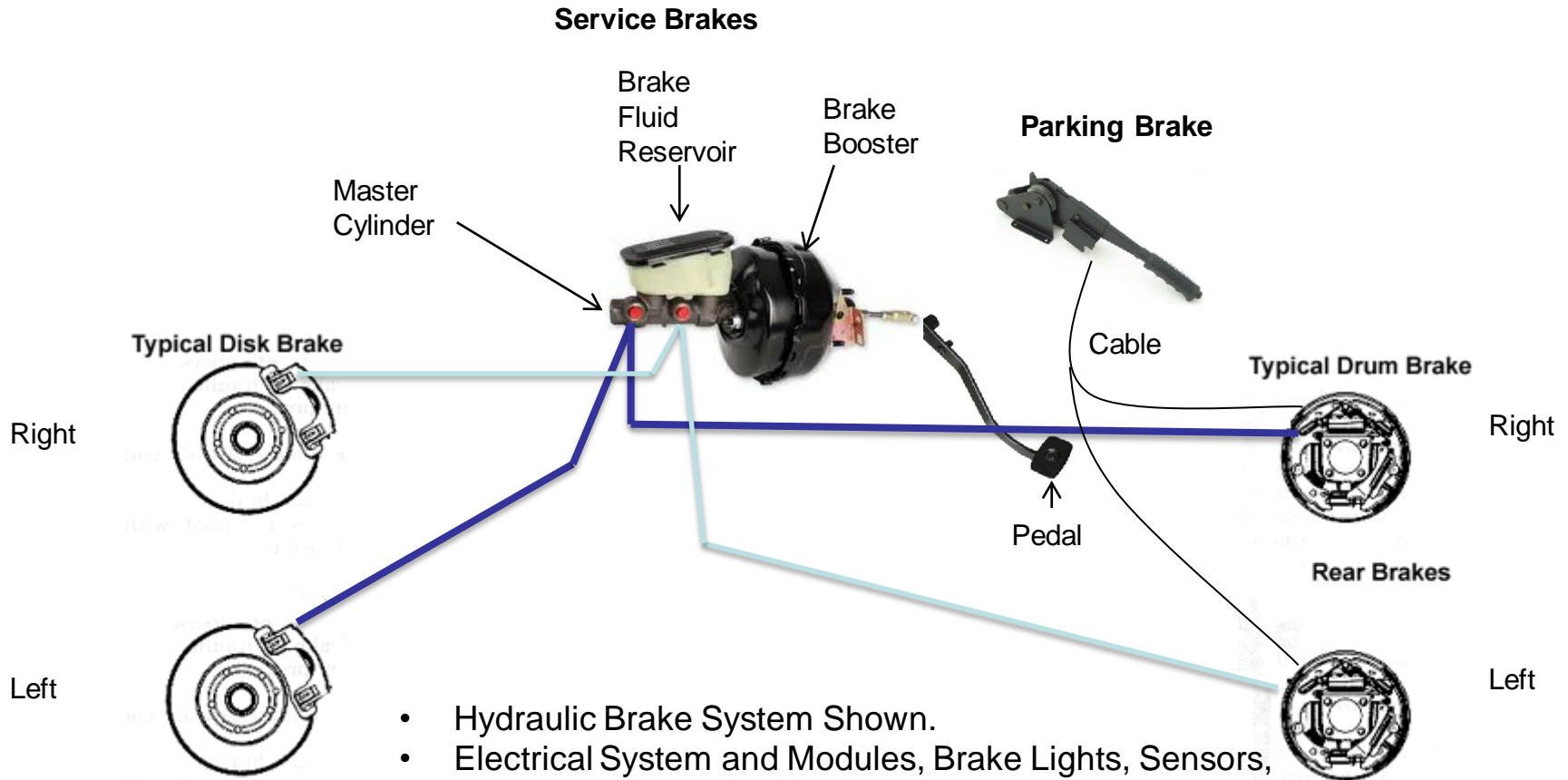
# Brake Design Standards

- The National Highway Transportation Safety Administration (NHTSA) promulgates the safety standard for vehicles under the Federal Motor Vehicle Safety Standard (FMVSS).
- Requirements for brakes systems are found within the FMVSS. See the following for a quick summary of FMVSS vehicle standards
- <https://www.govinfo.gov/content/pkg/CFR-2017-title49-vol6/xml/CFR-2017-title49-vol6-part571.xml>

# Passenger Car Brake System

- Passenger cars are required under 49 CFR 571.105 to have a service brake and a parking brake.
- Please read the following CFR (right click and open hyperlink) and take note of testing and performance requirements of S5.1:
- <https://www.ecfr.gov/current/title-49/subtitle-B/chapter-V/part-571/subpart-B/section-571.135>

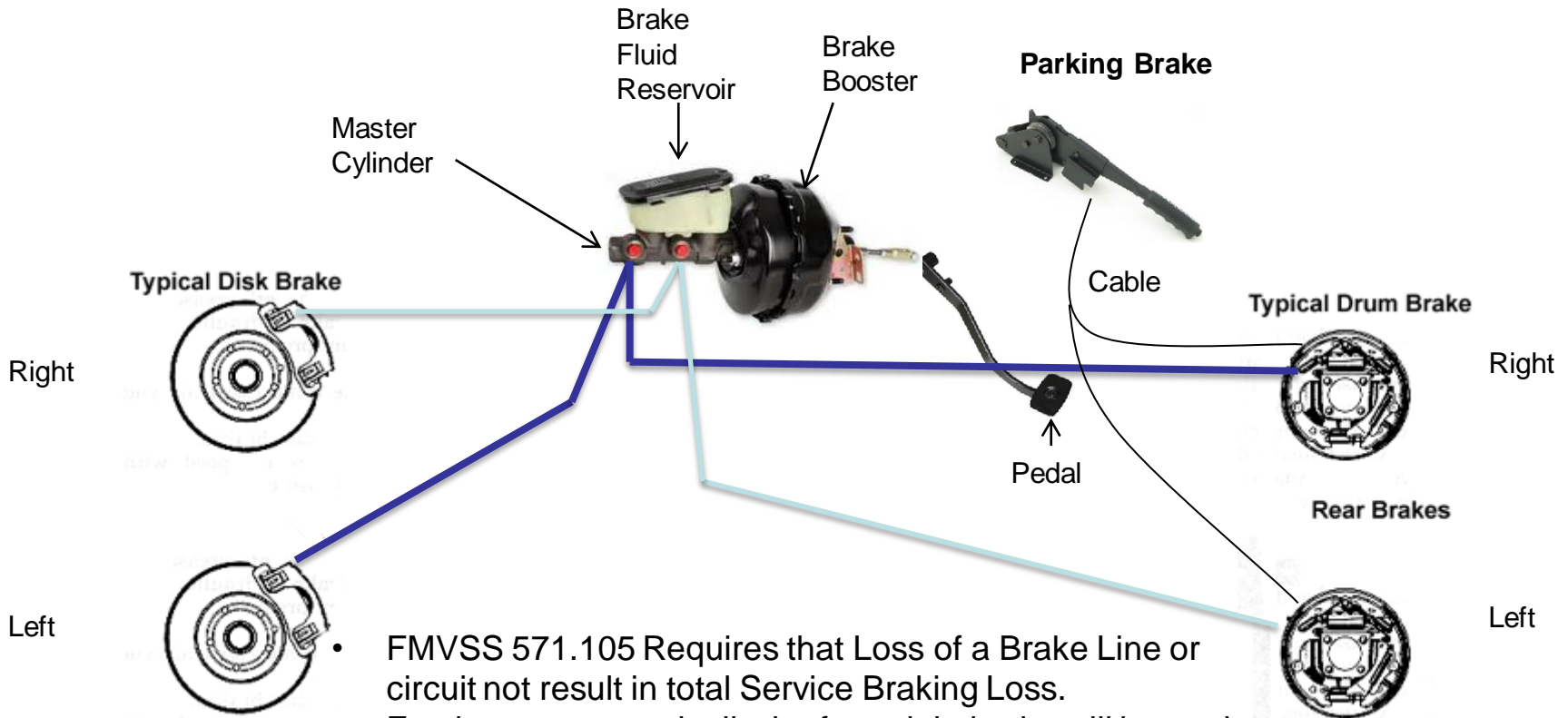
# Passenger Car Brake System



- Hydraulic Brake System Shown.
- Electrical System and Modules, Brake Lights, Sensors, ABS, and Traction Control Not Shown.
- Pedal to Master Cylinder Could be Electronic Instead of Mechanical
- Rear Brakes could also be Disk. More and more cars today have rear Disk Brakes
- Parking Brake could also be a Foot Pedal.

# Diagonal Braking

## Service Brakes



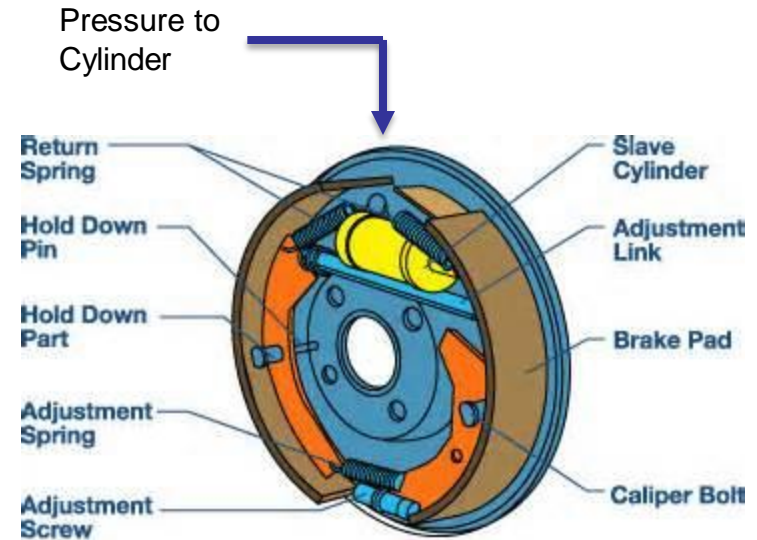
- FMVSS 571.105 Requires that Loss of a Brake Line or circuit not result in total Service Braking Loss.
- For that reason, typically the front right brake will be on the same circuit as rear left, and likewise for front left and rear right will be on the same circuit
- Alternatively the front right and left may be on separate circuits with a third circuit for the rear drum brakes.

# Passenger Car Advanced Braking Systems

- Please watch the following short videos explaining anti-lock braking system.
- ABS explained (right click and follow hyper link):  
<https://youtu.be/ru4JIZ-x8yo>
- Predictive Braking Systems may pre-apply braking force to reduce the human perception reaction time or apply the brakes. See:  
<http://youtu.be/VHR8AeZrIVc>
- Adaptive Braking – adapts to the driver and weather conditions.  
See: <http://youtu.be/sAu5ilf9qhk>
- This following European NCAP system is for optional viewing:  
<http://youtu.be/sh0YTnWp3Cl>

# Drum Brakes

- Drum brakes historically the oldest mass produced passenger car brake design.
- Drum brakes are durable and mechanically simple.
- Drum brakes are typically enclosed thereby preventing fouling.
- Drum brakes do not provide the braking efficiency of caliper brakes.
- Drum brakes are commonly found today at the rear wheels in combination with caliper brakes on the front wheels.
- Drum brakes are harder to service than disc brakes, but last typically twice as long as caliper brakes

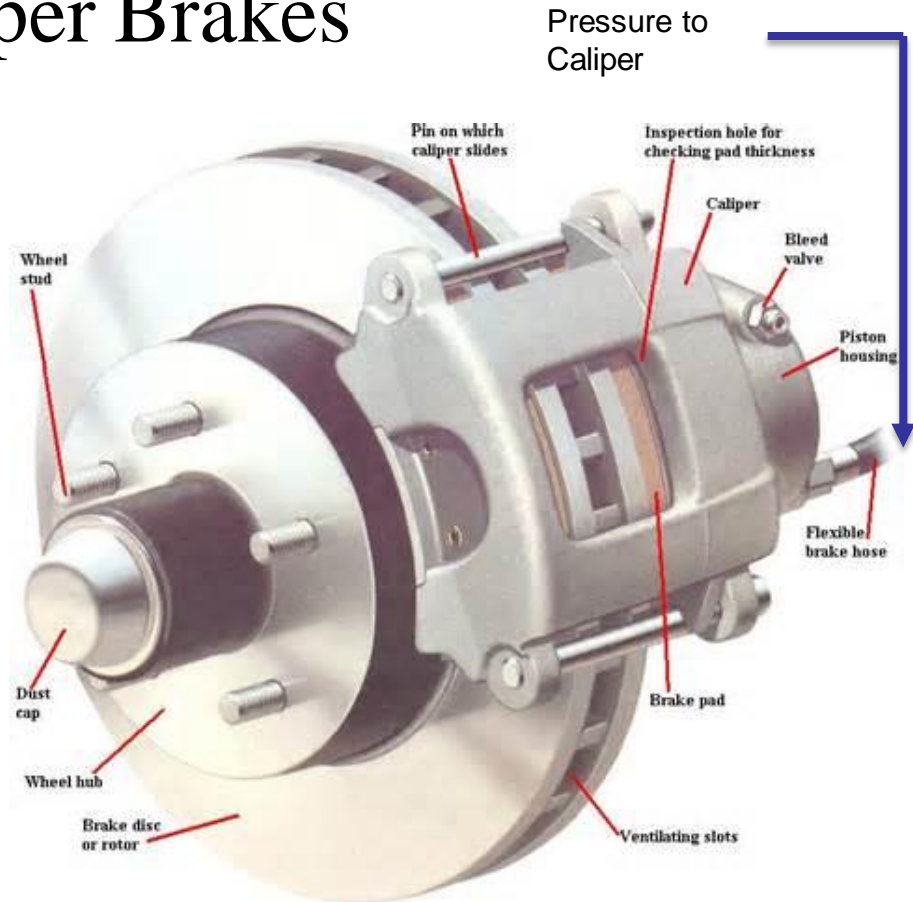


- Pressure in Cylinder Pushes Pistons Outward
- Pistons Pushes Brake Shoe Pads Outward
- Pads contact the Inside of Drum Spinning with Wheel Hub



# Caliper Brakes

- Caliper brakes provide greater braking stability than drum brakes.
- Caliper brakes at the front are generally relied upon to provide a majority of the braking force on a vehicle.
- Caliper brakes generally require greater servicing than drum brakes.
- Caliper brake pads generally wear out twice as fast as drum brake shoes.
- Caliper brakes are more prone to making unwanted noises.



- Pressure in Caliper Squeezes Brake Pads
- Brake Pads Squeezes the Brake Rotor

# Brake System Design

- Brake system design is a balancing act involving the brakes, the tires, the suspension, and the weight balance of the vehicle.
- The front and rear brakes have to be tuned for performance.
- Take 10 minutes or so to review the following:
- <http://www.mre-books.com/sa126/brakes4.html>



# Passenger Car Brake Defect Investigations

- By far, the most common claim during a brake defect investigation is the claim that the car failed to stop when brake pedal was depressed.
- Unlike a tire failure analysis or investigation, typically the brake systems and components are better preserved during a motor vehicle accident.
- More commonly available today is Electronic Data Recorder (EDR) data from airbag and supplementary restraint systems. Typically brake pedal switch position is recorded.
- Some advanced EDR systems can even record brake system pressures.

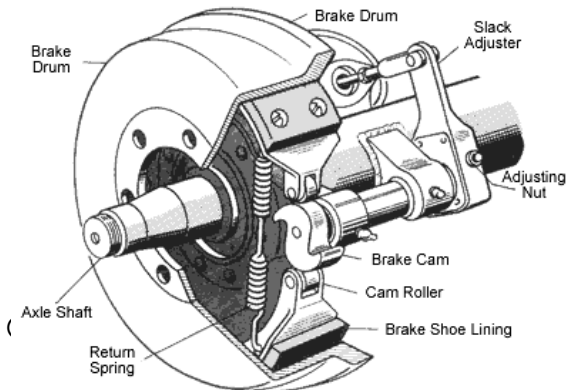
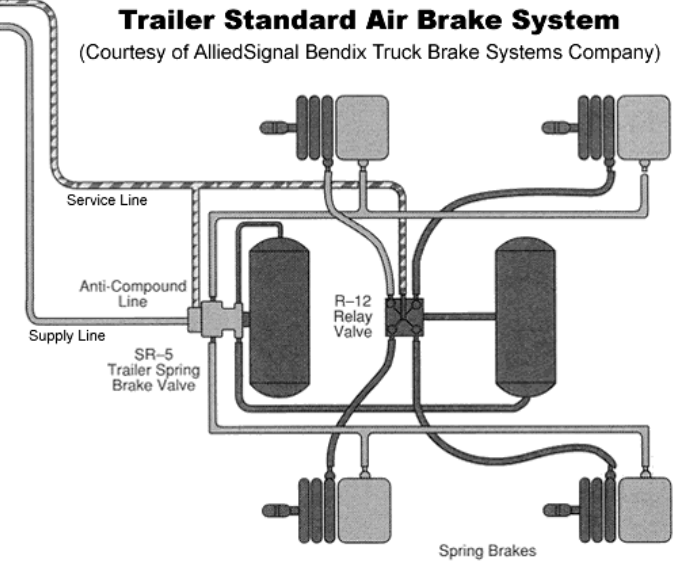
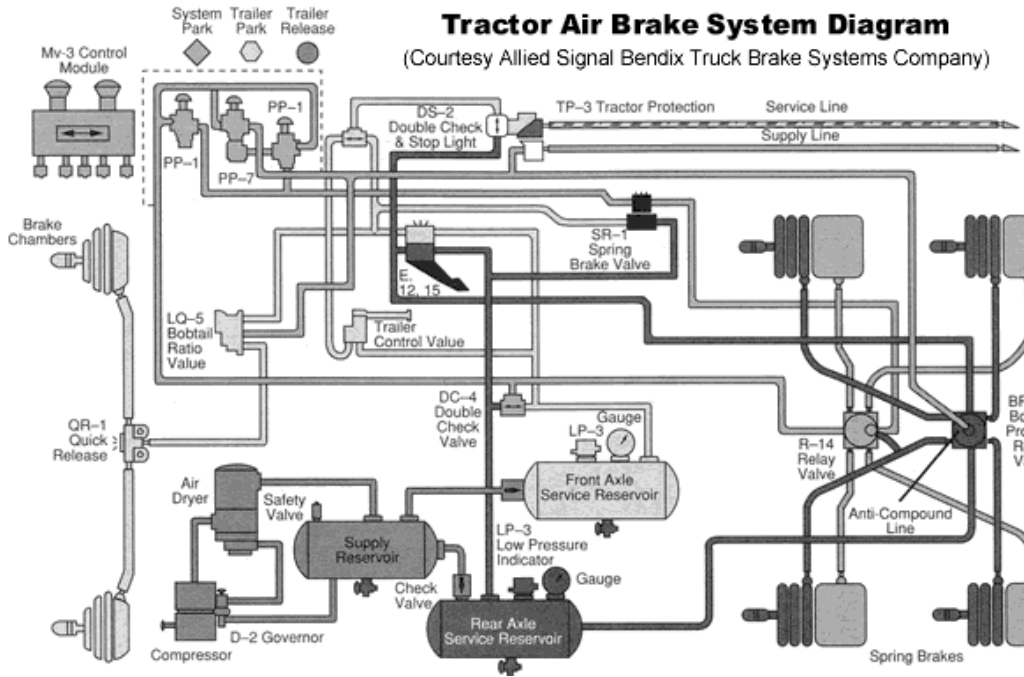
# Passenger Car Brake Defect Investigations (cont.)

- Vehicle and brake system must be inspected (if possible) by the forensic engineer. Disassembly will be required.
- Any recorded electronic data must be preserved.
- If possible, vehicle may be powered and the brake system tested with or without wheels on.
- Fluid samples may be taken from the brake system if necessary.
- Electrical engineers or software engineers may be necessary to evaluate advance braking system hardware, software, and design.
- Brake service history may be evaluated for maintenance.

# Typical Failure Modes

- Worn Pads on Caliper Brake Pads or Drum Brake Shoes. Failure to maintain or replace.
- Breached brake lines. Corrosion, mechanical failure of connections, or undercarriage collision damage (i.e. driving over truck tire treads).
- Failure of the brake booster or electronic braking assist.
- Failure of the ABS or electronic system or control between the pedals and the brakes.

# Commercial Truck Braking System



Courtesy of Allied Bendix Truck Brake Systems Company

# Commercial Truck Braking System

- Truck Brakes Performance Requirements Also Covered Under 49 CFR 571.
- Biggest Difference to Passenger Cars are Brake System is Pneumatic (Air) vs. Hydraulic.
- Spring Brakes are Similar to Drum Brakes Except They are Normally On.
- Air Pressure is Used to Release Brakes, and Modulation of the Air Pressure Provides Service Braking.
- Please watch the following video focusing on video after 4 minutes: <http://youtu.be/-R7J9BIjNEw>

# Commercial Truck Forensic Investigation

- Commercial Truck Brake Investigation has a greater degree of complexity.
- Loss of air pressure is a common failure mode.
- Loss of air pressure may be due to operator error, or pumping brakes.
- There are a lot more air lines and pressurized tanks to visually inspect.
- There are a lot more brake shoes to examine and measure.
- If the system hasn't lost integrity, then brake stroke has to be measured for each chamber with parking brake off.
- Performance test the parking braking, service brake, and governors for the pressure chambers.