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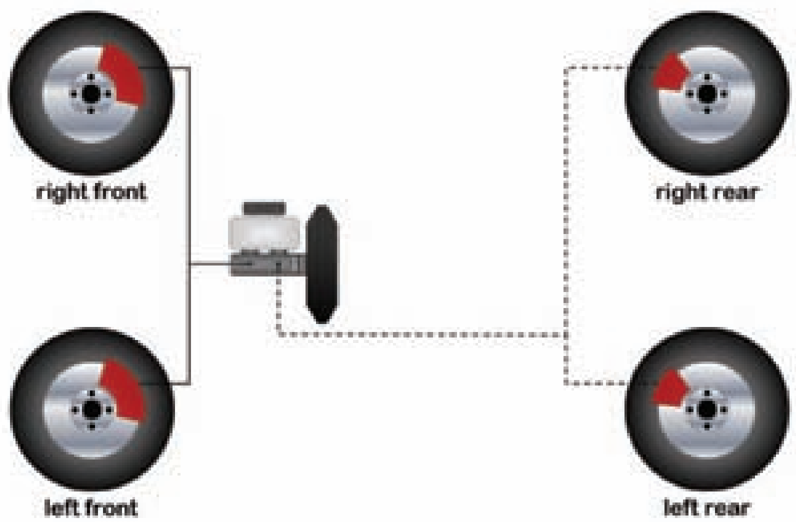
Brake Lines and Hoses

As stated back in Chapter 3, the brake lines and brake hoses have one of the easiest jobs in the brake system. They only need to transport pressurized brake fluid away from the master cylinder and to the four corners of the car. On the surface, it sounds like a simple job.

However, while the brake lines and hoses have a relatively straightforward role to play in the brake system, if they're unable to perform their task, everything goes really bad, really fast. There are few brake system failures that draw as much immediate attention as a hydraulic fluid leak. So while the job at hand may be a simple one, the importance is no less significant than for any other brake system component.



In a front-rear split design, the two front brakes (solid line) and two rear brakes (dashed line) use independent hydraulic circuits. This architecture is most common in rear-wheel drive vehicles and/or pickup trucks due to their significant rear weight distribution and large rear-brake assemblies.

Hydraulic Circuit Design

In Chapter 5 it was briefly stated that all modern vehicles employ two completely separate hydraulic circuits to direct brake fluid pressure to the four corners of the vehicle. This step is taken in the interest of safety—if one circuit fails and is unable to generate pressure, the other remains capable of providing at least some level of brake system functionality.

Front-Rear Split

One of the simplest methods for achieving brake system redundancy is to attach the front brakes to one dedicated hydraulic circuit while placing the rear brakes on their own separate hydraulic circuit. Generally referred to as a *front-rear split*, this hydraulic architecture is found on vehicles that have relatively uniform front-to-rear static weight distributions.

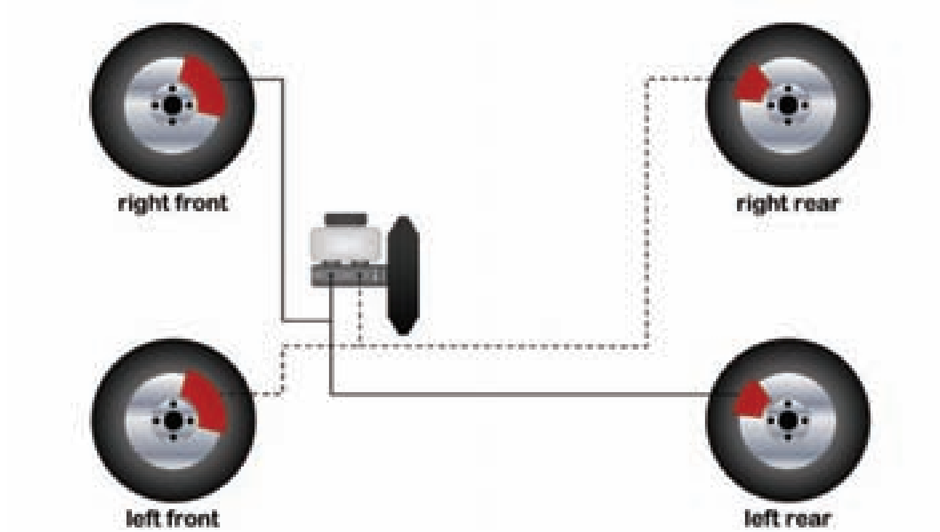
The primary performance advantage of the front-rear split design is that in the event of a failed hydraulic circuit, there are still two brakes on the *same* axle that provide equal braking forces. For this reason, the vehicle won't turn or pull in either direction under failed-circuit braking.

From a manufacturing perspective, a front-rear split design only requires that a single hydraulic line be routed from the master cylinder to the rear of the vehicle. Once the hydraulic line reaches the rear axle it can be split to provide pressure to both the left rear and right rear brakes, but a single hydraulic line can be used for a majority of the distance.

One potential disadvantage of the front-rear split is that the level of deceleration available under failed-circuit braking varies with which axle experiences a hydraulic failure. In the case of a failed rear hydraulic circuit, the driver retains braking on the front axle, but a failed front circuit only leaves the driver with the rear brakes to slow the vehicle. Because the gain of the front brakes is generally much greater than the gain of the rear brakes, this can result in a significant variation in performance between the two failed conditions.

Diagonal Split

In some applications, the gain of the rear brakes may be low enough that a completely failed front hydraulic circuit would not allow the vehicle to decelerate at an



If a vehicle has a significant percentage of its weight carried on its front axle, the rear brake gain may be too low to achieve an appropriate level of deceleration during failed-circuit braking. For this reason, smaller vehicles with front-wheel drive typically employ a diagonally split hydraulic arrangement where the right front is paired with the left rear, and the left front is paired with the right rear.

acceptable level. Therefore, an alternate hydraulic design known as the *diagonal split*, or X-*split*, connects one front and one diagonally opposed rear brake assembly (the left front brake and right rear brake, for example) to each hydraulic circuit. In this fashion, regardless of which hydraulic circuit fails the remaining braking capacity is the same.

Although this symmetry in design may appear highly desirable at first, it creates its own unique performance compromise. Because the front brake gain and the rear brake gain are quite different from one another, a failed diagonal circuit will create a brake force distribution that causes the vehicle to pivot around the functioning front brake, resulting in a pull. This tendency can be amplified by vehicle suspension parameters, but fundamentally all vehicles equipped with diagonally split hydraulic circuits will try to change lanes under failed-circuit braking conditions.

In addition, the diagonal split implementation requires that two hydraulic lines be routed from the master cylinder to the rear of the vehicle. For this reason, the more complex diagonal split is also less preferred from a manufacturing and servicing perspective, but if the rear brakes are relatively small, there may not be another option.

Brake Lines

A typically hydraulic circuit consists of both *brake lines* and *brake hoses*. The difference between them is that brake lines are fabricated from mild steel, while brake hoses are made from flexible, polymeric materials.

Brake lines are typically attached to the master cylinder at one end, snaked around the vehicle like spaghetti, and terminate at the brake hose somewhere near the moving parts of a vehicle's chassis. In order to protect them from damage, brake lines are typically made from mild steel and are permanently bent to route their way around and along the vehicle's underside. For additional protection, they are usually held in place along the body with plastic clips or retainers—a brake line hanging out in midair is just asking to get caught, snagged, or otherwise damaged by a passing piece of road debris.

Smaller vehicles with smaller compliances require 3/16-inch brake lines as shown on the left, while large vehicles with excessive compliance require 3/8-inch diameter sewer pipes as shown on the right. If the brake line selected is too small in diameter, it will increase the brake system response time. (Randall Shafer)

Because a brake line failure can be quite catastrophic, it makes sense to route them up and out of the way of any potential hazards. Clips and brackets should be used to attach individual lines to the vehicle body structure adding yet another layer of protection. (Randall Shafer/StopTech)

Another benefit of mild steel construction is that it decreases the brake line's compliance. Remember back from Chapter 3 that when a hydraulic system is pressurized it wants to expand in volume like a balloon. Mild steel helps add mechanical strength to the line, reducing its expansion when subjected to brake fluid pressure.

Flare Fittings

In order to form a leak-proof seal with the master cylinder and brake hose, a *flare*