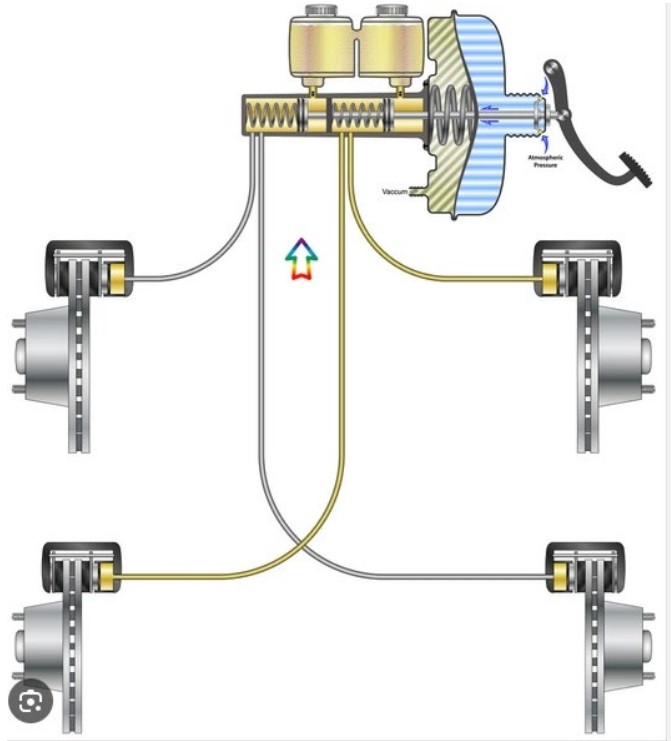
- Request 5

- Describe in detail the overall brake system design for the subject vehicles and peer vehicles, and how the hydraulic circuits are split. Also, describe in detail how the loss of different parts of the brake system would impact the overall braking performance of the vehicle, in both an acute failure scenario and a prolonged failure scenario. Please include details regarding the loss of one part of a circuit (i.e. rear brake) as well as loss of an entire circuit.

The 2015-2019 Edge and 2016-2018 MKX Vehicles have a power brake system that includes a vacuum booster and dual master cylinder to initiate brake actuation.

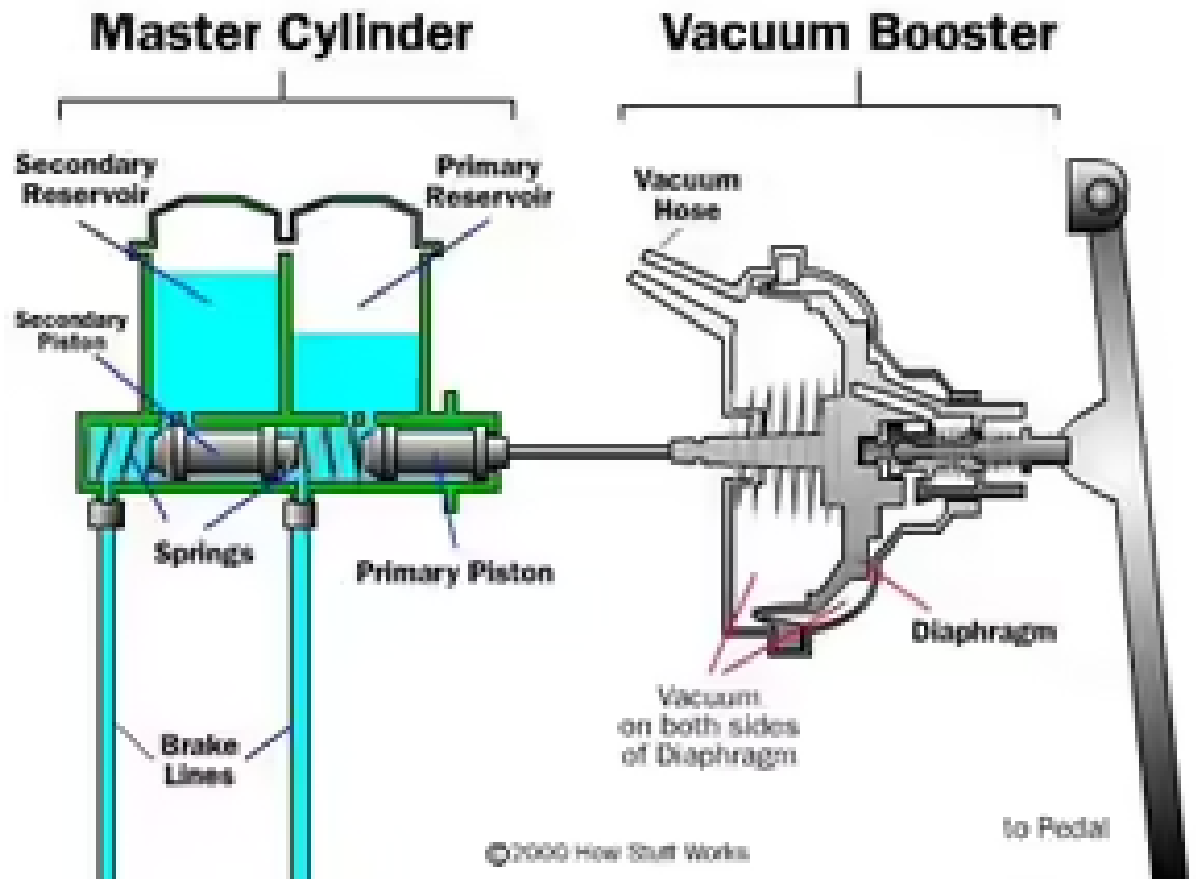
Brake Actuation System Diagram



The Vacuum Booster

- The engine provides a vacuum source for the vacuum booster through a tube and hose assembly.
- The brake pedal pushes a rod that passes through the booster into the master cylinder, actuating the master-cylinder piston. The engine creates a partial vacuum inside the vacuum booster on both sides of the diaphragm. When the brake pedal is applied, the rod cracks open a valve, allowing air to enter the booster on one side of the diaphragm while sealing off the vacuum. This increases pressure on that side of the diaphragm so that it helps to push the rod, which in turn pushes the piston in the master cylinder.
- As the brake pedal is released, the valve seals off the outside air supply while reopening the vacuum valve. This restores vacuum to both sides of the diaphragm, allowing everything to return to its original position.

Vacuum Booster Diagram



The Master Cylinder

- The hydraulic system is split into two isolated circuits, primary and secondary. One side of the master cylinder serves the Right Front and Left Rear brakes, the other side of the master cylinder serves the Left Front and Right Rear brakes.
- When the brake pedal is applied, it pushes on the primary piston through a linkage. Pressure builds in the cylinder and lines as the brake pedal is depressed further. The pressure between the primary and secondary piston forces the secondary piston to compress the fluid in its circuit. If the brakes are operating properly, the pressure will be the same in both circuits.

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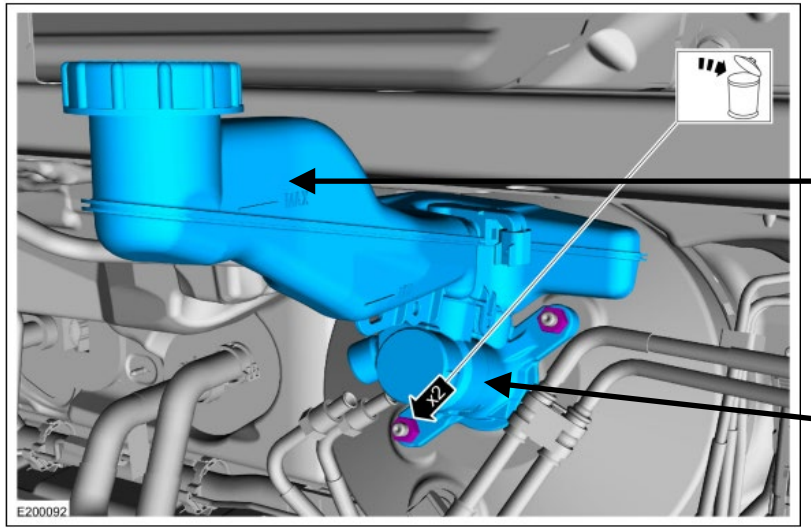
Edge/MKX Master Cylinder



Fluid reservoir

Master cylinder

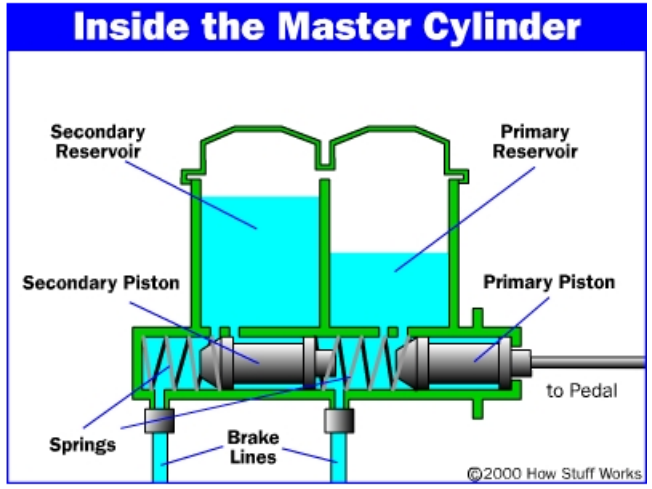
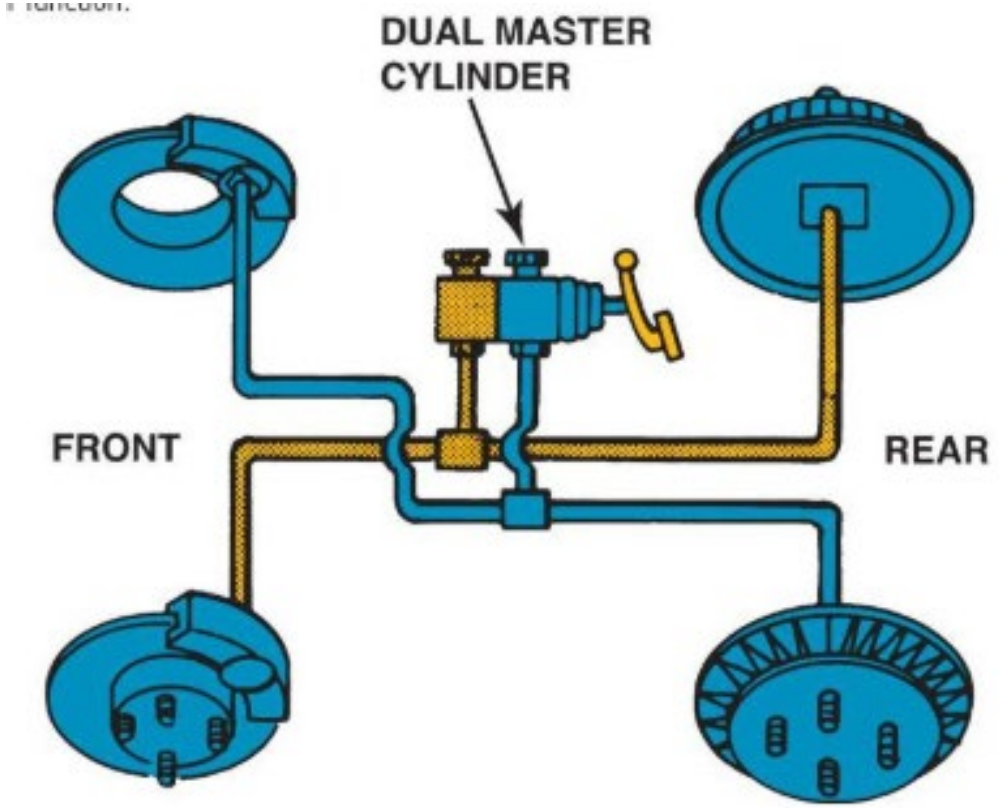


Diagram of master cylinder

Master Cylinder Two Circuit Plumbing



Brake System Controls

- The 2015-2019 Edge and 2016-2018 MKX vehicles are equipped with an Anti-Lock Brake System (ABS), an Electronic Stability Control system (ESC) and Electronic Brake Distribution (EBD). The operation of these brake control systems is not provided because Ford believes it is outside the scope of this PE; however, the consequence of a leak in one of these systems is covered in our description of brake fluid leaks.

One Brake Inoperative

- If one brake is inoperative due to an internal failure (not a leak) the other three brakes will work.

External Fluid Leak In One Circuit

- If there is a leak in one of the circuits (at the master cylinder, ABS unit, brake lines/hoses or caliper), that circuit will not be able to maintain pressure.
- When the first circuit leaks, the pressure between the primary and secondary cylinders is lost. This causes the primary cylinder to contact the secondary cylinder. Now the master cylinder behaves as if it has only one piston. The second circuit will function normally, but the driver may have to press the pedal further to activate it. Since only two wheels have pressure, the braking power will be reduced.

Single Brake Hose Fluid Leak

- If a rear brake hose develops a leak, the driver may experience an increase in pedal travel, but the driver will be able to bring the vehicle to a stop. If the customer continues to drive the vehicle, a leaking brake hose will cause the brake fluid level in the master cylinder reservoir to decrease. When the level reaches the “Low” mark on the reservoir, the red brake warning indicator light will illuminate, providing overt notification to the driver that there is a problem with the braking system. If the customer continues to drive the vehicle with brake warning light illuminated, the brake fluid in the affected circuit of the master cylinder may become empty which will result in a reduction in the rate of deceleration. The brake system is split diagonally, and one circuit in the master cylinder is isolated (protected) and will always have fluid, so two of the vehicle’s four brakes will always work if a hose is leaking. This allows the vehicle to be stopped safely even if one circuit is leaking. The Subject and Peer vehicles meet FMVSS 135 S7.10 Hydraulic circuit failure performance requirements.

Ford test drive of a brake hose leak on a CD4 Platform Vehicle (Edge/Fusion)

- In 2022, in order to better understand the effect of a leaking brake hose, Ford installed a field return hose that exhibited the alleged defect (leaking) on a Ford CD4 platform vehicle, in this case a Fusion. The brakes initially behaved normally for two separate drivers during 10 medium to heavy brake applications. One driver succeeded in causing the ABS to activate during a simulated emergency stop. The driver then noticed that the brake pedal travel was longer after the vehicle was stopped. Following the ten brake applications the red brake warning light came on, and the brakes continued to function, with a longer pedal, giving the driver time to stop safely before losing all the brake fluid in the one leaking circuit. This Ford test drive confirmed that a customer who experiences a leaking front brake jounce hose will receive overt warnings (a longer brake pedal and a red brake warning light) before experiencing reduced brake performance.

VOQ Customer Interviews from 2022

In 2022, in order to better understand the customer's experience Ford obtained permission to contact two customers who wrote VOQs alleging reduced braking due to leaking front brake hoses. NHTSA provided the customer contact information. The details of these two interviews are as follows:

Customer #1 - 2015 Fusion

- First Incident: the customer noticed a change in the brake pedal feel when he slowed down for a speed bump. He drove home carefully and found the driver's side front hose was split and leaking. He installed a new hose.
- Second Incident: at a later date, the customer was driving on the highway and pressed the brake pedal to disengage cruise control and noticed the brake pedal did not feel normal, the pedal travel was longer. He drove home carefully and noticed fluid leaking on the ground and the brake fluid reservoir was empty. He does not remember if the brake light was on. He replaced the leaking hose himself. He indicated in the interview that the brakes were working but did not want to brake hard because he did not have confidence in them. He was aware of the Edge recall and was wondering if this hose was similar and created the VOQ so that NHTSA would be aware of this incident.

Customer #2 - 2017 Fusion

- The customer noticed the brake pedal was spongy for a day or two before the incident. He never saw fluid leaking. One day he noticed the brake light was on in the morning and the brake pedal travel was longer than normal so he drove the car carefully to a mechanic. He indicated in the interview that the brakes were working but he did not want to brake hard because he did not have confidence in them.

The two customers interviewed both indicated a loss of confidence in the brake system; however, customers chose to continue to drive the vehicle cautiously and indicated that they did not lose the ability to stop. This feedback from VOQ customers is consistent with the findings of our vehicle test drive at Ford and supports Ford's assessment that this is a progressive issue and customers can safely stop and park the vehicle after they realize the brake pedal travel has become longer and the red brake light has come on.