



AEROSPACE INFORMATION REPORT

AIR6441™

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Reaffirmed 2025-04

Information on Parking Brake Systems

RATIONALE

The industry requested that general reference information on parking brake system architectures be compiled including a discussion of various parking brake related issues.

AIR6441 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This SAE Aerospace Information Report (AIR) provides information on the parking brake system design for a variety of aircraft including part 23, 25, 27, and 29. The document includes a discussion of key technical issues with parking brakes. This document does NOT provide recommended practices for parking brake system design.

1.1 Purpose

This AIR has been prepared by a panel of the SAE A-5A Committee and is presented to document the design approaches and service experience from various applications of parking brake systems. This experience includes commercial and military applications.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS8584A Brake Systems, Wheel, Military Aircraft

2.1.2 Other Publications

FAR 25.671 / CS 25.671 General (Control Systems Design & Construction)

FAR 25.735 / CS 25.735 Brakes and Braking Systems

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Documents

Standard, visit Sharing Hub

AC 25.735-1 / AMC 25.735	Brake and Braking Systems Certification Tests and Analysis
FAR 25.703 / CS 25.703	Takeoff Warning System
AC 25.703-1 / AMC 25.703	Takeoff Configuration Warning Systems
AC25.1309-1A	System Design and Analysis

2.2 Abbreviations and Acronyms

AAIB	Air Accidents Investigation Branch
AC	Advisory Circular
A/S	Antiskid
BBW	Brake By Wire
CFR	Code of Federal Regulations
CS	Certification Specifications (EASA)
EMA	Electromechanical Actuator
FAA	Federal Aviation Administration
FSDO	Flight Standards District Office
MOV	Motor Operated Valve
NTSB	National Transportation Safety Board
PB	Parking Brake
PBOV	Park Brake Operating Valve
SOV	Solenoid Operated Valve
MLG	Main Landing Gear
OEM	Original Equipment Manufacturer
UAV	Unmanned Air Vehicle
V/STOL	Vertical/Short Takeoff and Landing
VTOL	Vertical Takeoff and Landing

2.3 Definitions

ACCUMULATOR: A device or apparatus that stores hydraulic fluid under pressure in order to have that energy available at a later time when the normal hydraulic pressure generating system (pump) is off or failed.

ELECTRIC BRAKE: A brake that employs linear electromechanical actuators to apply a clamping force to the wheel driven rotor(s).

EMERGENCY BRAKE: A system or apparatus for applying brakes when the normal control or power system has failed.

HOLDING BRAKE: A system and/or apparatus for applying brakes to hold the aircraft for an intermediate length of time while the aircraft is operating. A holding brake usually utilizes the same brake assemblies, control and power sources as normal braking. It is often used to relieve pilot or equipment workload in maintaining static brake pressure. In most aircraft, the holding brake and park brake functions are served by the same system. Another key aspect of a holding feature is that the torque requirement would usually be just enough to hold against idle thrust on a level surface, significantly lower than the parking requirements described in Section 3.

PARK BRAKE: A system and/or apparatus for applying brakes to park the aircraft for an extended length of time. The PB usually utilizes the same brake assemblies as for normal braking but with different control and power sources. A PB usually provides for parking pressure to be maintained when the a/c systems are turned off. They are also sometimes referred to as Power Off Parking Brake.

PARK BRAKE VALVE: The hydraulic valve which controls the parking function. It either applies parking pressure from an independent source, or isolates the already applied pressure in order to maintain pressure for parking.

3. PARKING BRAKE REQUIREMENTS

CS 25.703:

A take-off warning system must be installed and must meet the following requirements: (a) The system must provide to the pilots an aural warning that is automatically activated during the initial portion of the takeoff roll if the airplane is in a configuration, including any of the following that would not allow a safe take-off: (3) The parking brake is unreleased.

FAR 25.735 / CS 25.735:

The airplane must have a parking brake control that, when selected on, will, without further attention, prevent the airplane from rolling on a dry and level paved runway when the most adverse combination of maximum thrust on one engine and up to maximum ground idle thrust on any, or all, other engine(s) is applied. The control must be suitably located or be adequately protected to prevent inadvertent operation. There must be indication in the cockpit when the parking brake is not fully released.

Following the high kinetic energy stop demonstration(s) required by paragraph (f) of this section, with the parking brake promptly and fully applied for at least 3 minutes, it must be demonstrated that for at least 5 minutes from application of the parking brake, no condition occurs (or has occurred during the stop), including fire associated with the tire or wheel and brake assembly, that could prejudice the safe and complete evacuation of the airplane.

AC 25.735-1 / AMC 25.735:

It should be demonstrated that the parking brake has sufficient capability in all allowable operating conditions (Master Minimum Equipment List (MMEL) to be able to prevent the rotation of braked wheels. This demonstration is to be accomplished with the stated engine power settings, and with the airplane configuration (i.e., ground weight, CG position and nosewheel (or tailwheel) angle) least likely to result in skidding on a dry, level runway surface (refer to § 25.735(d)). Use of ground idle thrust on the "other" engine is not mandatory, higher thrust levels may be used to prevent airplane motion due to the asymmetric engine thrust. Where reliable test data are available, substantiation by means other than airplane testing may be acceptable.

1. For compliance with the requirement for indication that the parking brake is not fully released, the indication means should be associated, as closely as is practical, with actual application of the brake rather than the selector (control). The intent is to minimize the possibility of false indication due to failures between the brake and the point at which the parking brake state is sensed. This requirement is separate from, and in addition to, the parking brake requirements associated with JAR 25.703(a)(3)/CS 25.703 and AMC 25.703, Take-off warning systems.
2. The parking brake control, whether or not it is independent of the emergency brake control, should be marked with the words "Parking Brake" and should be constructed in such a way that, once operated, it can remain in the selected position without further flight crew attention. It should be located where inadvertent operation is unlikely, or be protected by suitable means against inadvertent operation.

FAR 23 / CS 23:

No parking brake requirements specified.

AS8584A:

Unless otherwise specified a parking brake system shall be provided on all aircraft. The parking brake shall be located and actuated in accordance with MIL-STD-203. A "PARK-ON" indicator in the crew station or an automatic release shall be provided. The parking brake shall provide sufficient braking force in the brake system to develop a torque to hold on a 33-degree slope for shipboard aircraft at maximum design gross weight and a 12-degree slope for land based aircraft at a design alternate gross weight. The parking brake system shall include means to compensate for predicted leakage and temperature variations in the ambient environment and brake system components so that at least 75% of the parking brake torque defined above is maintained over a minimum period of 24 hours with engines off. Temperature increases above the initial parking temperature shall not result in excessive pressure in the brake system. No pumping shall be required in order to meet the parking requirements.

AC25.1309-1A:

The requirements of 25.1309-1A are intended to ensure a thorough evaluation of the effects of foreseeable failures on system functions. The parking brake system for part 25 aircraft must be designed to be compliant with the intent of AC25.1309-1A including the quantitative thresholds for minor, major, and catastrophic failure conditions, and the requirement that no single point failure may result in a catastrophic failure condition. Of particular interest for the parking brake system is the uncommanded application of parking pressure which is generally considered of catastrophic severity.

4. PARK BRAKE SYSTEM CONFIGURATIONS

4.1 Parking Brake Types Requiring Pedal Application

In this type, application of the parking brake relies on the main braking system and depressing the pedals to provide the parking pressure. Pressure is then trapped by means of the parking brake mechanism. In Figures 1 through 5 below, the red lines are system pressure, the black lines are normal and parking pressure, and the gray lines are return.

4.1.1 Isolation Valve in Brake Line

In this architecture, parking is achieved by pressing the pedals followed by closing a 2 way isolation valve in the brake lines (downstream of the a/s valve, if applicable) thus trapping the applied pressure. Figure 1 describes this type of PB in a simple master cylinder brake system. Figure 2 shows this type of PB in typical powered brake system. This method of PB would also be applicable to a BBW system similar to what is shown in Figure 2. Although an electric powered valve is possible, the valve control is most often a direct mechanical connection with the park brake lever in the cockpit. Once the valve is closed, the pedals may be released and park pressure will be retained. Release of park brake pressure is achieved by simply opening the valve. This type of system is used on many aircraft including the Cessna Citation series.

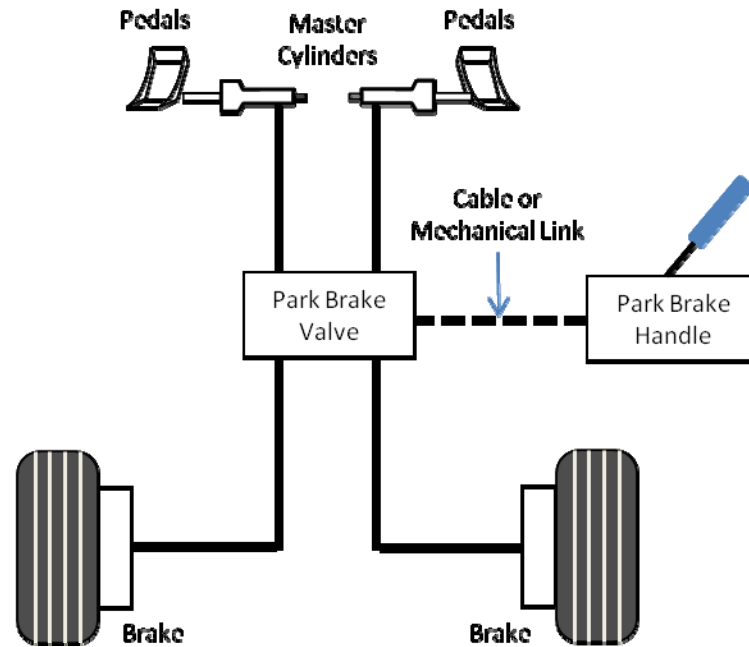


Figure 1 - In-line valve in master cylinder system

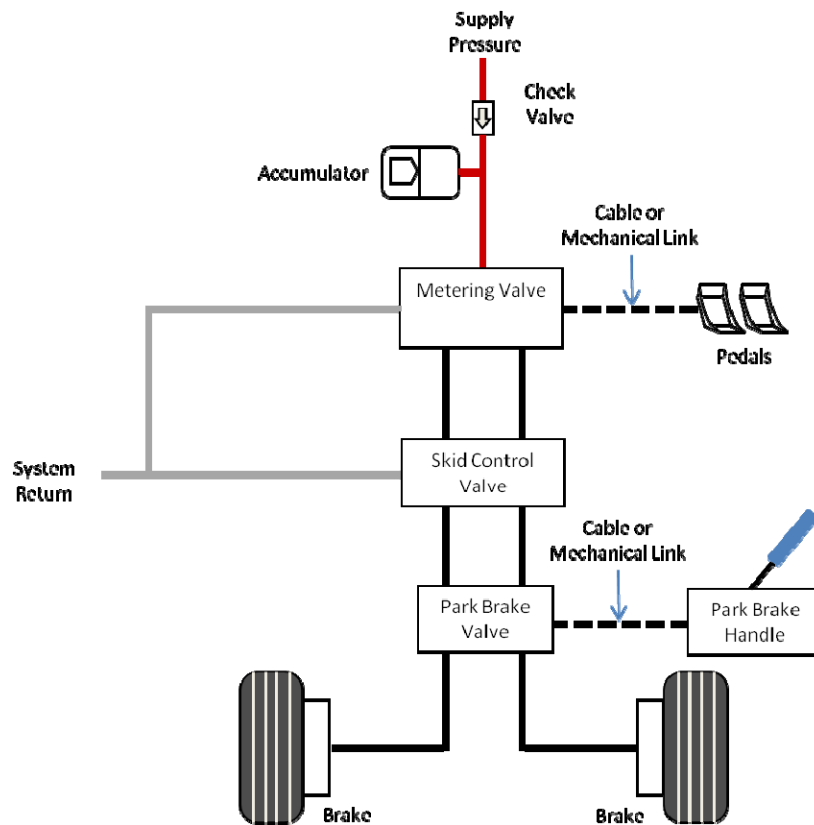


Figure 2 - In-line valve in powered system

4.1.2 Latching

In this second alternative, park pressure is again provided by depressing the pedals. However, instead of trapping pressure with a valve, this method traps pressure by a mechanical latch. The latching may be done in the pedal mechanism, the master cylinders, or the metering valve(s). Figure 3 shows a simple latching PB with a master cylinder brake system.

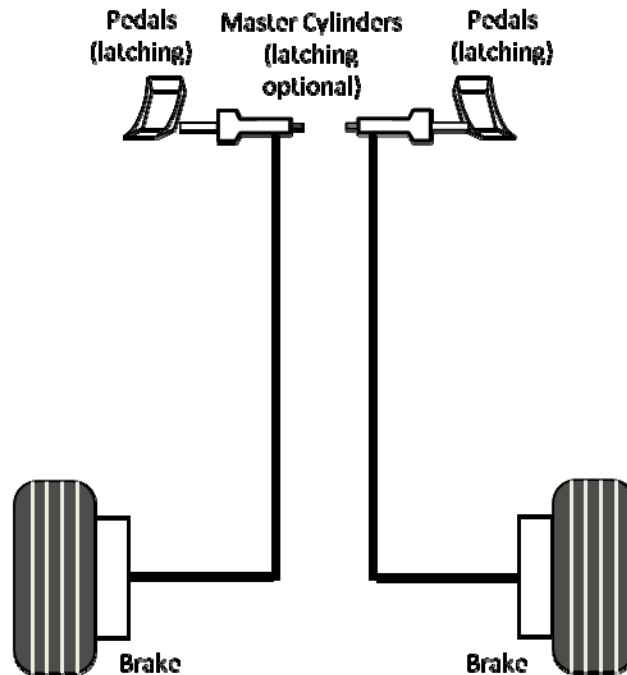


Figure 3 - Pedal latching PB in master cylinder system

4.1.3 Latching with Valve in Return Line

In more sophisticated brake systems, an additional isolation valve is required in the return line to minimize leakage to return. The isolation valves may be mechanical or solenoid operated. Also, the isolation valve may shut off the return from just the antiskid valve (as shown in Figure 4) or it may shut off the return from both the metering and the antiskid valves. One example of this type is the Canadair CRJ series where the latching is done in the brake metering valve and the return line isolation valve is a solenoid type. The Boeing 737 is another example of a parking brake system with latching pedals and an isolation valve in the return line.