

# National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



ERA22LA150

## **SYSTEMS**

Group Chair's Factual Report

December 04, 2023

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## **A. ACCIDENT**

Location: Pittsburgh, PA  
Date: March 9, 2022  
Time: 0827 eastern standard time  
1327 universal coordinated time (UTC)  
Airplane: HondaJet HA-420 S/N 42000224, JetIt LLC, N903JT

## **B. SYSTEMS GROUP**

|              |                                                                       |
|--------------|-----------------------------------------------------------------------|
| Group Chair  | John Flynn<br>National Transportation Safety Board<br>Washington D.C. |
| Group Member | Gerald Labuskes<br>Federal Aviation Administration<br>Washington D.C. |
| Group Member | Thomas Sully<br>Honda Aircraft Company<br>Greensboro, NC              |

## **C. SUMMARY**

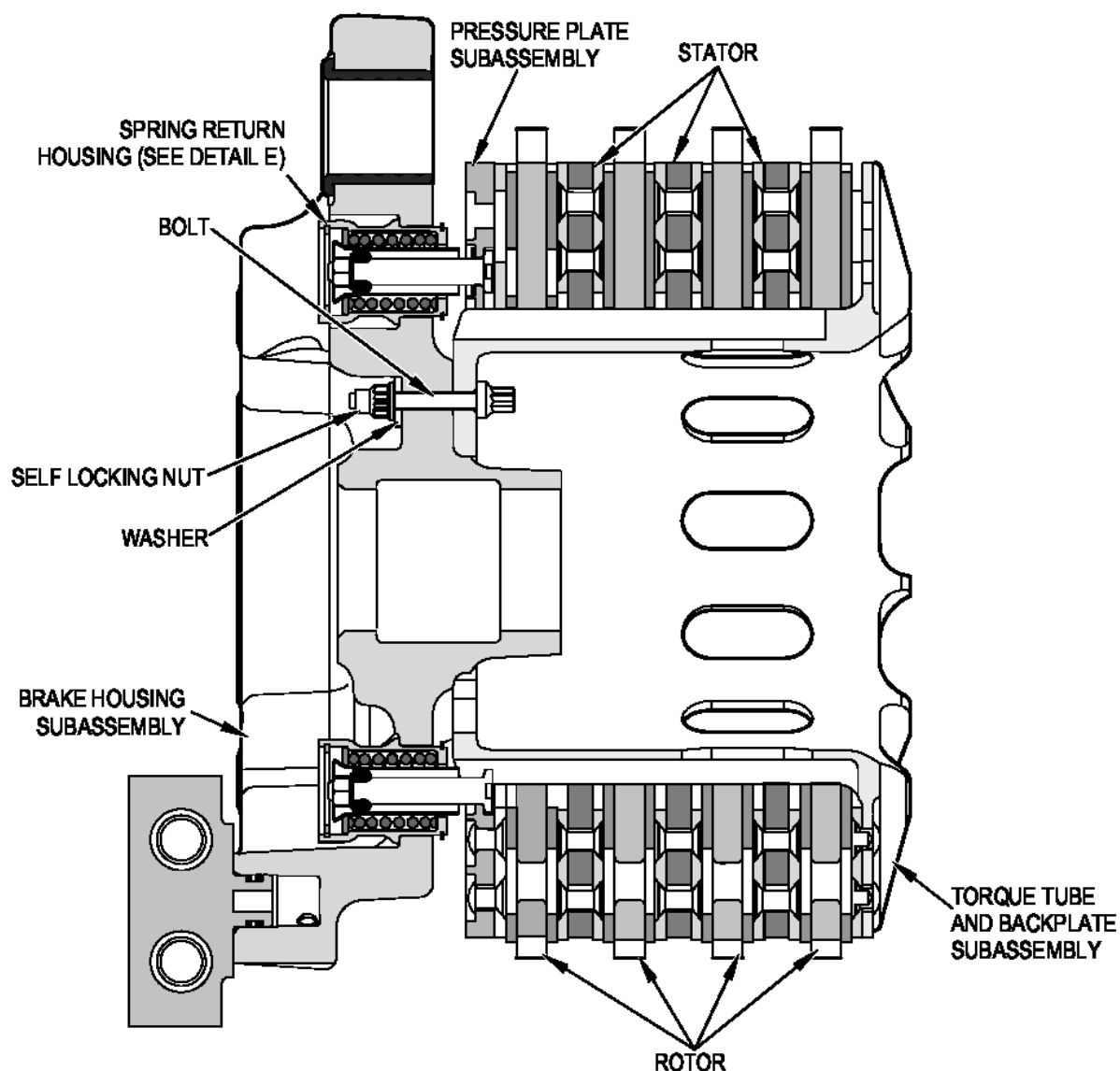
On March 9, 2022, about 0827 eastern standard time, a Honda Jet HA-420, N903JT, was substantially damaged when it was involved in an accident near Pittsburgh, Pennsylvania. The two pilots and one passenger were not injured. The airplane was operated by JetIt, LLC as a Title 14 Code of Federal Regulations Part 135 air taxi flight.

Weather conditions at the time of the accident included ½ statute mile visibility, light snow, and an overcast ceiling at 400 ft. The airport ATIS reported at the time of the approach and landing included a Braking Action Advisory with a braking action report of “good” by a Pilatus at 0755 and a field condition NOTAM reporting 10% runway coverage with 1/8-inch slush on the landing runway.

## D. DETAILS OF THE INVESTIGATION

### 1.0 Brake System Description

Each main landing gear is equipped with a multiple disc brake that uses four rotating steel discs and three stationary steel discs. A brake assembly can be used on either the left or the right axle. The brake assembly contains a cylinder housing with four piston assemblies, a shuttle valve, one bleed port, two visible wear indicators, four adjuster assemblies, a backplate, a torque tube, and a pressure plate. The rotor assemblies are located between the pressure plate, stationary disc, and back-plate assemblies. (See Figure 1.)



**Figure 1.** Schematic of brake assembly (Courtesy of Honda Aircraft Company)

The brake application is initiated by a force on the brake pedals located at the top of the rudder pedals, which provides the control pressure to the master cylinders. The amount of braking force is proportional to the force applied to the brake pedals. Braking occurs when the pressure plate touches the stators, which push against the rotors. Braking can start at pressures as low as 100 to 150 pounds per square inch (PSI). Maximum operating hydraulic pressure is 3,000 PSI. When brake pressure releases, the piston separates from the pressure plate.

An automatic adjuster keeps clearance as brake wear occurs. This clearance keeps a constant operating fluid displacement. Brake wear indicator pins are installed on the pressure plate and protrude through the cylinder housing. The brake wear indicators provide a visual indication of brake lining wear. When the brakes are applied, and the indicators are flush with the cylinder housing, then the brake pads are worn and need replacement.

## **1.1 Power Brake and Anti-Skid Control**

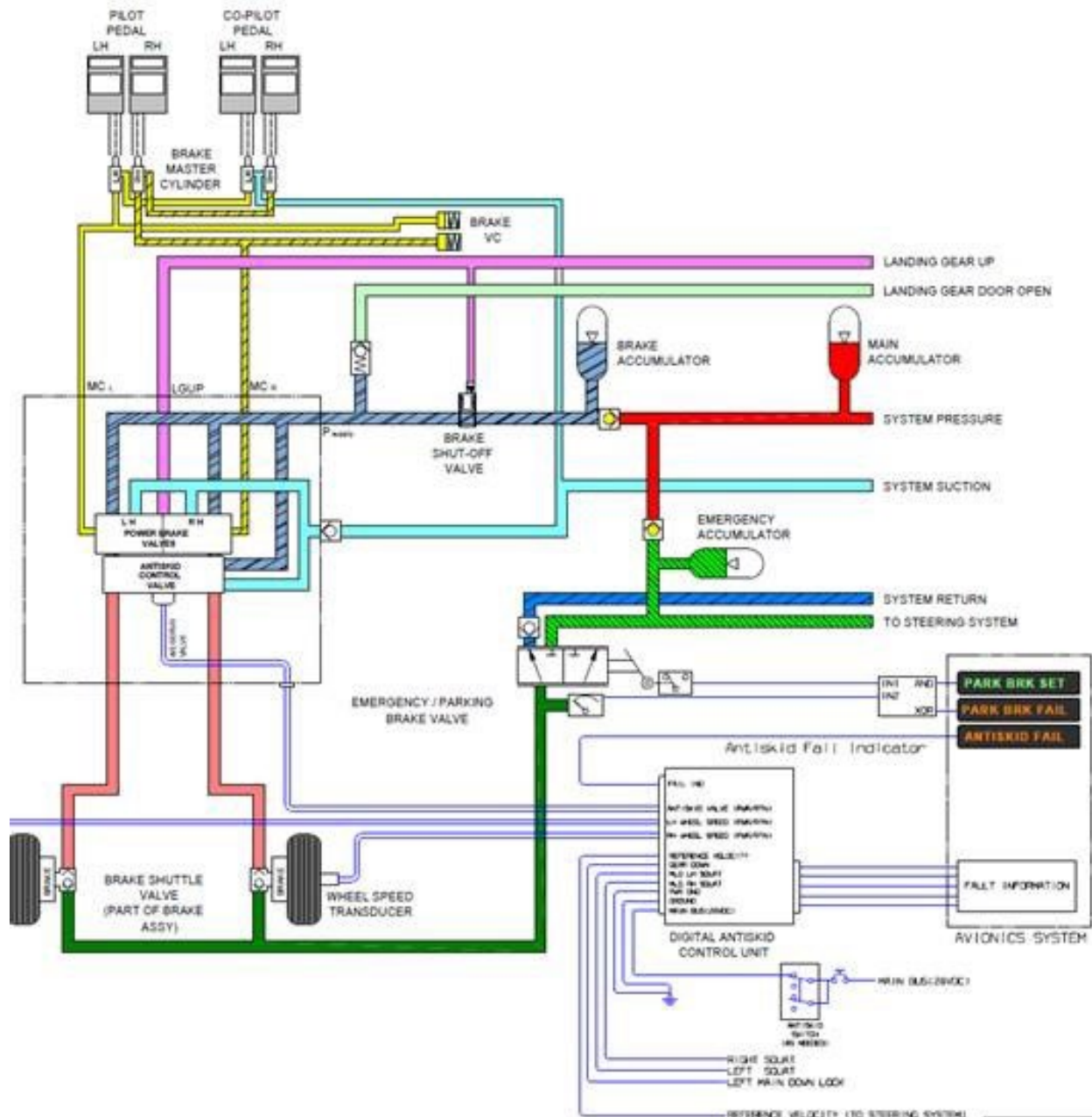
The normal power brake system contains an anti-skid control function. There are two modes of braking: power brake or power brake with anti-skid. The brakes are normally operated in the power brake with anti-skid mode. The brakes operate in the power brake mode when an anti-skid control signal is not available.

If power to the anti-skid system or an anti-skid control signal is not available, the anti-skid system will not operate. If the anti-skid system is not in operation, then power brakes without anti-skid are available by a force applied to the brake pedals which supply a control pressure at the master cylinders. Master cylinder stroke is dependent on the fluid displaced by the volume compensator. A brake shutoff valve downstream of the brake accumulator functions as a leak-free interface between the brake accumulator and the normal brake system when the landing gear is retracted.

If there is power to the anti-skid system and there is an anti-skid control signal, then the anti-skid system is on. This is the normal state of the system and the anti-skid system will give protection to the power brake system. This protection is available when the aircraft wheel speed is above approximately 10 knots and below approximately 165 knots (190 mph). The digital anti-skid control unit (DACU) uses the wheel-speed transducer to determine wheel skid and then outputs a signal to the power brake/ anti-skid control valve to release both brake pressures at the same time. The automatic anti-skid function goes back to the standby mode after wheel skid stops or the pilot reduces the brake pedal force which decreases the brake pressure below the wheel skid level.

The major components of the system are as follows (See Figure 2):

1. Digital anti-skid control unit (DACU) located in the pressurized aft cabin and attached to the left fuselage side wall.
2. Power brake/anti-skid control valve (ASV) located aft of the wing rear spar to the left of the aircraft centerline.
3. Master cylinders (MC) located below the cockpit floor and attached to the brake pedals.
4. Volume compensators (VCs) located aft of the wing rear spar on the aircraft centerline.
5. Brake shutoff valve (SOV) located aft of the wing rear spar on the aircraft centerline.
6. Wheel speed transducers (WST) located in the main landing gear axles.



**Figure 2.** Brake system schematic. (Courtesy of Honda Aircraft Company)

### 1.1.1 Digital Anti-skid Control Unit

The DACU is a digital (microprocessor) control unit that supplies the functions for anti-skid control. The DACU contains the anti-skid control/built-in-test circuitry for two wheel control channels. Wheel speed data from both wheel speed transducers is received and processed, and an average wheel speed is calculated. Antiskid control calculations are done and a single anti-skid control signal is supplied to the valve supplying anti-skid protection to the left and right wheels. When operating with anti-

skid protection, both right and left brake pressures will be reduced because of the wheel anti-skid system operation.

The DACU provides the following: touchdown protection, wheel spin-down braking, locked wheel crossover protection, and built-in test (BIT) functions.

#### **1.1.1.1 Touchdown Protection**

Touchdown protection stops braking until the airplane wheels have reached a minimum speed of 60 kts. regardless of the position of the weight-on-wheels (WOW) switches (air or ground indication). If there is a weight-on-wheels signal for three seconds, power braking is enabled with or without a wheel speed signal.

##### **1.1.1.1.1 Wheel Spin-Down Braking**

The wheel spin-down braking function applies minimum wheel braking pressure during landing gear retraction to make sure that the main landing gear wheels have stopped rotating before they go into the wheel well. The power brake / anti-skid valve will apply minimum brake pressure during the gear retraction cycle until the inboard gear door is closed. While wheel spin down braking is not specifically a function of the DACU, the controller does inhibit touchdown protection during the landing gear retraction, allowing pressure to be supplied to the brakes.

#### **1.1.1.2 Locked Wheel Crossover Protection**

Locked wheel crossover protection starts if either wheel slows to 30% or less of the other wheels rotation speed. When this protection occurs, the brake system releases brake pressure to remove the locked wheel condition. This brake system release occurs in addition to the normal anti-skid function.

#### **1.1.1.3 Built-In Test Functions**

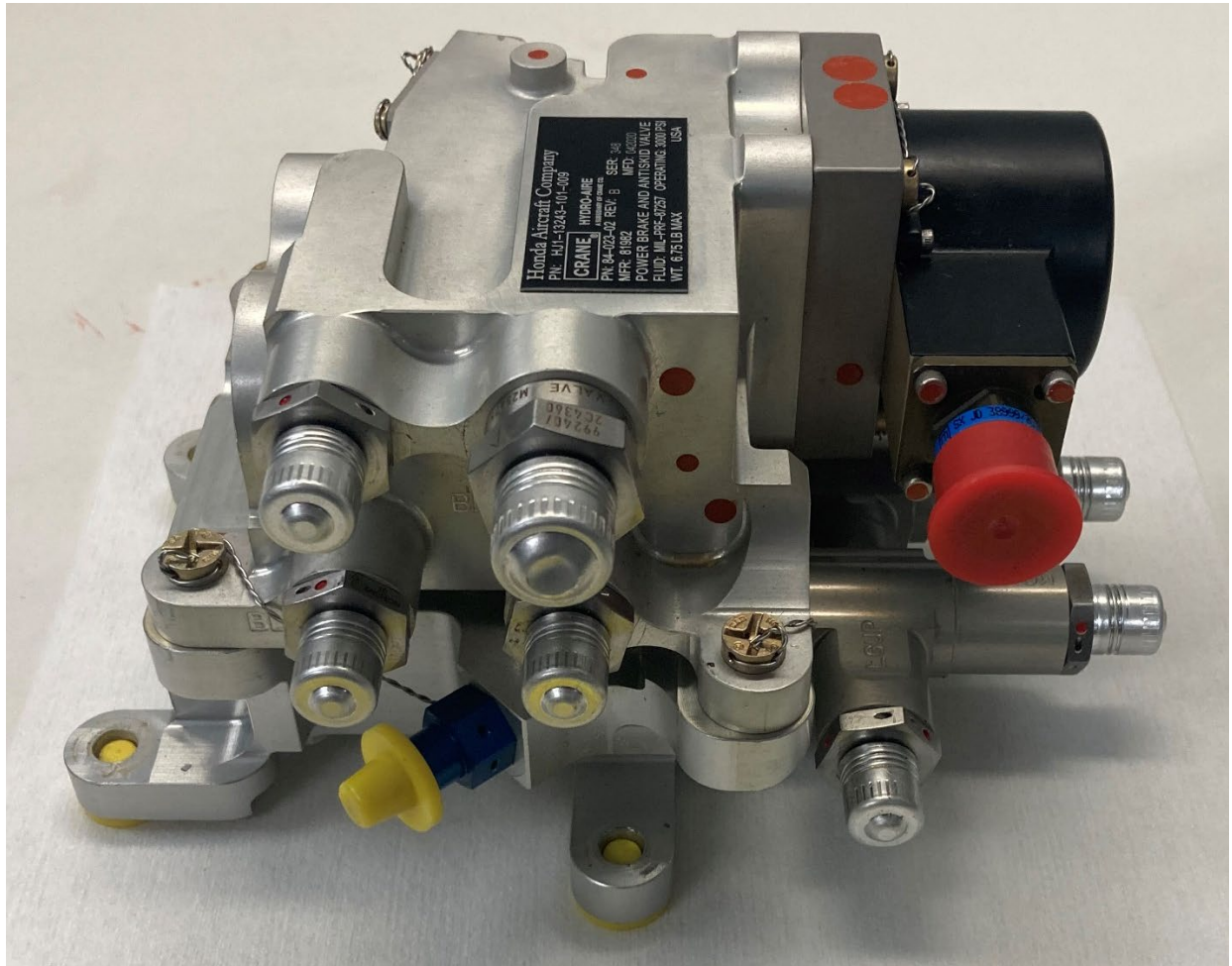
The BIT functions through the anti-skid control unit when power is applied to the system and the airplane WOW switches are in the air or ground position. This allows the automatic testing and continuous anti-skid system operational status monitoring. When a system failure is detected, a caution message will be displayed in the cockpit on the crew alerting system (CAS). Initialization testing will occur in flight if power is cycled to the anti-skid system.

Continuous monitoring is part of the BIT function and starts when power is applied to the anti-skid system. If the main gear WOW switches disagree for more than 60 seconds, a CAS message is shown on the primary flight displays (PFD).

A CAS message will also be shown on the PFD when the anti-skid control unit has no power.

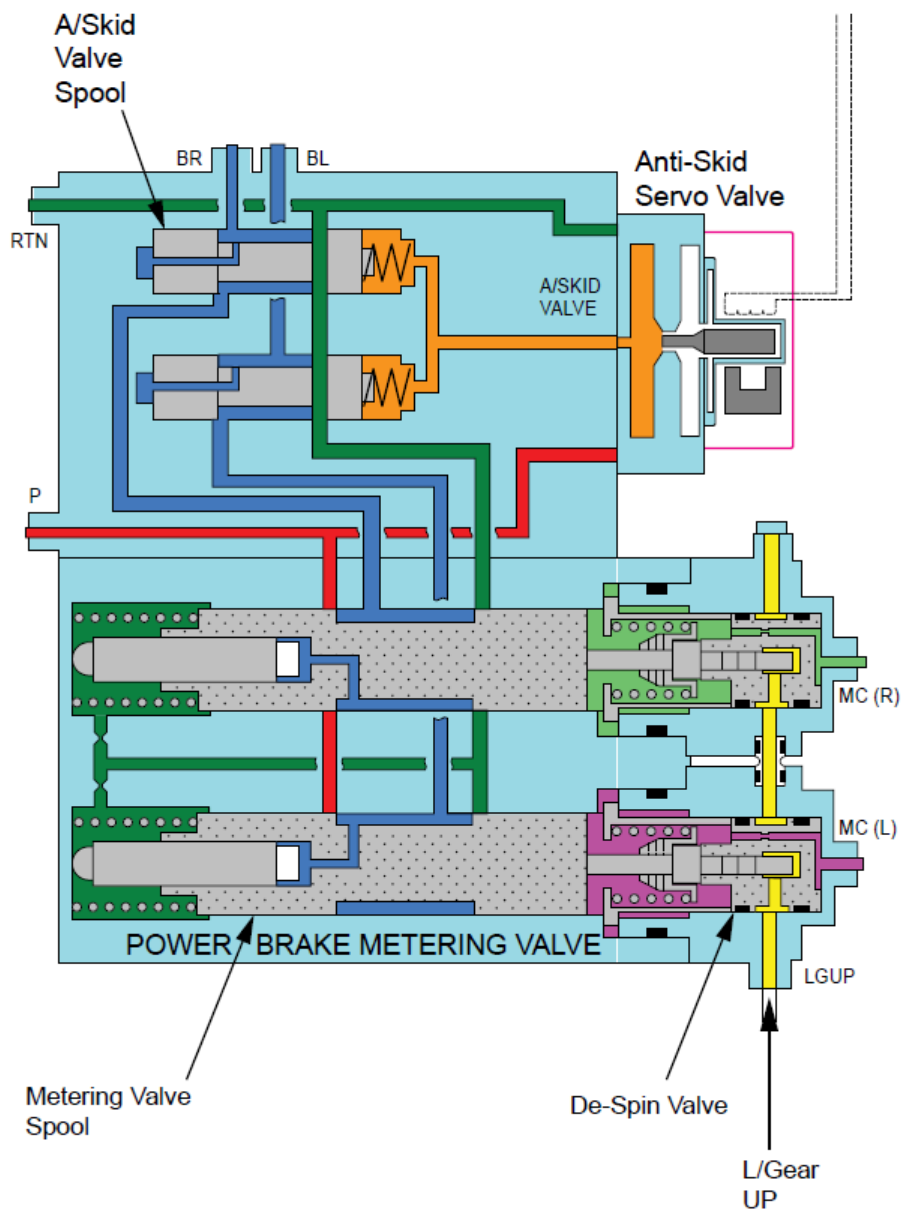
### 1.1.2 Power Brake/Anti-Skid Control Valve

The ASV is a metering/anti-skid valve that supplies hydraulic fluid as needed by the force applied to the brake pedals. It includes a servo valve that modulates pressure for anti-skid wheel control. A picture of the ASV is shown in Figure 3. A schematic of the ASV is shown in Figure 4.

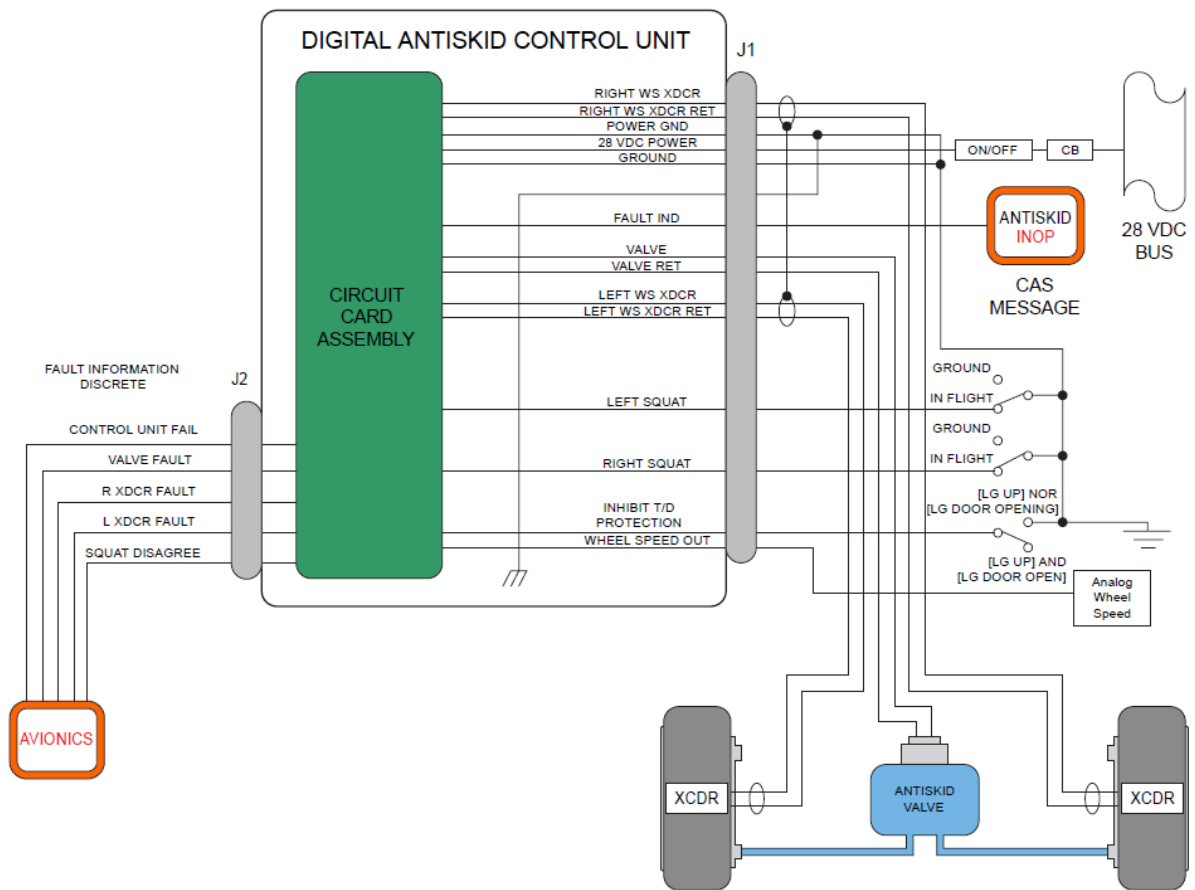


**Figure 3.** Power brake/anti-skid control valve.

- Master Cylinder Right Pressure
- Master Cylinder Left Pressure
- Supply Pressure
- Return Pressure
- Left Brake Pressure
- Right Brake Pressure
- Landing Gear Up Pressure
- Servocontrol Pressure



**Figure 4.** Power brake/anti-skid control valve schematic. (Courtesy of Honda Aircraft Company)



**Figure 5.** Brake anti-skid control schematic. (Courtesy of Honda Aircraft Company)

### 1.1.3 Master Cylinder

The master cylinder is a hydraulic actuator responsible for pressurizing the hydraulic fluid in the brake system based on the brake pedal command. There are four master cylinders installed on the aircraft, two of which are connected in series between the pilot and the copilot for braking the aircraft. Their operation is redundant between the two pilot seats.

### 1.1.4 Volume Compensator

There are two volume compensators (VCs) per aircraft, one for the left brake and one for the right brake. The VC is installed in the master cylinder command lines so the pilot, when operating the brakes, is provided a brake pedal deflection as more brake pedal pressure is applied. Without the VC, the brake pedal would have very small deflections with large changes in applied pressure.

### **1.1.5 Brake Shutoff Valve**

The SOV is designed to reduce system leakage while the aircraft is in air, which could cause a bleed down of the hydraulic system pressure and frequent pump cycling.

### **1.1.6 Wheel Speed Transducer**

The WSTs are electromagnetic devices that produce a sinusoidal signal at a frequency of 36 cycles per rotation. The speed of the aircraft can be calculated by the DACU. This speed is used to provide adequate brake control as well as anti-skid protection. There are two WSTs installed on the aircraft; one on each main landing gear.

## **1.2 Emergency/Parking Brake System**

The emergency / parking brake is a mechanically actuated power brake valve that meters brake pressure to both brakes in proportion to the emergency/ parking brake handle movement. The emergency / parking brake handle is connected to the valve by a mechanical linkage and a push-pull control cable. The emergency / parking brake pressure goes to each brake assembly through a shuttle valve. Parking brake function is supplied by locking the emergency / parking brake handle at the parking position with the emergency / parking brake handle set/release button located on the handle. The same set/release button on the handle is used to release the emergency/parking brake pressure.

The emergency / parking brake system uses pressure from the emergency accumulator which is separated from system pressure by a one-way check valve. The emergency brake system has a different pressure source and hydraulic tubes from the normal brake system. The accumulator is charged by hydraulic system pressure. The accumulator has sufficient volume for approximately six brake applications if the hydraulic pump is rendered inoperative.

The emergency / parking brake system has a thermal relief valve to prevent over-pressurization of the hydraulic tubes and brake assemblies when there is a change in thermal environments.

If the emergency brake accumulator pressure decreases below 2350 psi, a caution CAS message will be shown on the PFD. An advisory CAS message will be shown on the PFD when the parking brake is set and brake pressure is above 1500 psi.

A CAS caution message will be shown on the PFD if the parking brake is set and brake pressure is below 1450 psi to show that the parking / emergency brake system has failed. A separate caution CAS message will be shown if parking brake pressure is above 175 psi and airplane is in the air.

## 2.0 Brake System Checks

After the accident, Honda Aircraft successfully completed the following checks on the brake system:

1. Brake system bleed verification test. (AMM 29-00-01-600-801 Section 8)
2. Functional check of the parking brake / E-brake. (AMM 32-40-01-700-801 Section 2)
3. Check hydraulic pressure at brakes. (AMM 32-40-01-700-801 Section 1)
4. Functional test of the power brake and anti-skid valve. (AMM 32-40-05-700-801 Section 1)
5. Functional test of the anti-skid brake system. (AMM 32-40-02-700-801)

Additionally, fluid was drained from the master cylinders and reservoir. The fluid was sent to a laboratory for analysis. National Aerospace Standard (NAS) 1638 is a particulate contamination coding system used in the fluid power industry to simplify the communication of data from particle counters. It converts the particle counts at various size ranges into convenient broad-base classes. The lower the cleanliness class, the cleaner the fluid. The hydraulic system fluid cleanliness class required for the HondaJet is Class 9 or better. The fluid cleanliness class from the samples was out of limits. The fluid samples were taken by draining fluid from those components. The proper method of taking a fluid sample involves running the hydraulic system until it reaches normal operating temperature then taking a fluid sample. In addition, contamination could have entered the sample if the fitting were not thoroughly rinsed or cleaned before opening the port fittings.

| Location                      | Fluid Cleanliness Class per NAS 1638 |
|-------------------------------|--------------------------------------|
| Pilot's Right Master Cylinder | Class 12                             |
| Pilot's Left Master Cylinder  | Class 12                             |
| Reservoir                     | Class 10                             |

The power brake/anti-skid valve was removed from the aircraft and sent to the manufacturer for further testing.

## 3.0 Power Brake/Anti-skid Valve Examination

The group met at the Crane facility in Burbank, CA on 17 October 2022, to perform the examination and testing of the power brake/anti-skid valve (part number 84-023-02 Rev B and serial number 348). The examination consisted of visually examining the power brake/anti-skid valve, flushing the ports of the power brake/anti-skid valve, performing the Acceptance Test Procedure (ATP) TP-84-023-

02, and disassembling of the power brake/anti-skid valve. The pressure, return, brake left, brake right, master cylinder left, and master cylinder right ports of the power brake/anti-skid valve were flushed with alcohol and the fluid filtered through filter paper. The patch test results (see Attachments) showed some debris and high fluid cleanliness classes. Some of these ports have filter screens included in the port fittings. The filter screens can collect debris which were flushed out when the ports were flushed with alcohol. No failures or abnormalities were noted in the power brake/anti-skid valve's operation.

## **E. LIST OF ATTACHMENTS**

1. Attachment 1 – Patch Test Results from Power Brake/Anti-Skid Valve Pressure Port
2. Attachment 2 – Patch Test Results from Power Brake/Anti-Skid Valve Return Port
3. Attachment 3 – Patch Test Results from Power Brake /Anti-Skid Valve Left Master Cylinder Port
4. Attachment 4 – Patch Test Results from Power Brake/Anti-Skid Valve Right Master Cylinder Port
5. Attachment 5 – Patch Test Results from Power Brake/Anti-Skid Valve Left Brake Port
6. Attachment 6 – Patch Test Results from Power Brake/Anti-Skid Valve Right Brake Port

Submitted by:

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