VADEN® ORIGINAL

TECHNİCAL GUİDE

Brake Caliper Mechanism: Camshaft, Bearings, and Return Spring

Inside the truck air disc brake caliper: how the camshaft, thrust bearings, return spring and automatic adjuster turn push-rod force into pad pressure.

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In the workshop, a tractor unit's rear axle is raised and the wheel is turned by hand. A light drag on the disc is normal, but this one is different: the wheel gives a faint "tick" at the same point on every rotation. On another vehicle the symptom is the opposite — the brake pedal is released, yet the pad will not release from the disc, and within a few kilometres the rim is too hot to touch. Neither symptom originates in the caliper housing itself; both trace back to a hidden mechanism inside it: the camshaft, its bearings, the return spring, and the adjuster gear assembly. Together these four components turn the straight-line push from the brake chamber into the force that clamps the pad against the disc. This guide covers that internal mechanism of the air disc brake caliper from end to end — how it works, how it fails, and how it is replaced.

This document was prepared by the VADEN technical team for heavy commercial vehicle air disc brake systems. The values given here are general reference figures only; for exact data, the vehicle's current OE service manual matching its engine and chassis code is authoritative. Last updated: September 2026. The function and terminology of the air disc brake caliper are defined within the scope of ECE R13 (UN braking regulation) and ISO 611 (braking terminology for road vehicles).

What is the caliper mechanism? Function and operating principle

The caliper mechanism is the internal assembly of an air disc brake that converts the linear push force from the brake chamber into the force that clamps the pad against the disc. It consists of the camshaft (eccentric shaft), the bearings that support it, the return spring that pulls the assembly back to its starting position when the brake is released, and the adjuster gear assembly that automatically keeps the running clearance constant as the pad wears. Together, these four components let the caliper generate braking force consistently and predictably.

The force chain works as follows: when the brake pedal is pressed, air pressure is applied to the chamber, and the chamber's pushrod is connected to a lever that projects outside the caliper. This lever transmits a rotating motion to the camshaft inside the caliper housing. As the eccentric profile on the camshaft rotates, it displaces the bridge plate seated on it linearly toward the disc. The bridge pushes the tappets connected to the adjuster gear assembly; the inner pad contacts the disc first, and the resulting reaction force slides the caliper housing along its guide pins so that the outer pad is also pressed against the disc. The result is that a single chamber stroke clamps both pads against the disc with equal force.

The mechanism's second function is leverage: the geometry of the crank arm amplifies the comparatively modest force from the chamber before it reaches the pad. Its third function is repeatability — the caliper mechanism has to maintain the same clearance and the same force-travel relationship over thousands of brake applications; otherwise pedal feel changes, brake response time lengthens, or the pad wears prematurely.

How does the camshaft (eccentric shaft) work?

The camshaft is a steel shaft positioned on a horizontal axis inside the caliper housing, with one end receiving the rotating motion from the chamber lever. It carries an eccentric or cam profile offset from its centre line; as the shaft rotates, this profile pushes the bridge plate, converting

rotary motion into linear motion. The camshaft's rotation angle is limited — not a full revolution, but a few degrees are enough to bring the pad into contact with the disc. This small angle allows both fast response and precise force control.

Why are the bearings (thrust bearings) needed?

Bearings or slide bushings sit at both ends of the camshaft and on the surfaces where the bridge plate slides inside the housing; needle bearings are the common solution in heavy-duty calipers. The bearings' job is to minimise friction — the lower the friction, the greater the share of the chamber's force that reaches the pad, and the smaller the share converted into heat. The bearings also keep the camshaft centred on its axis; once they wear, radial play develops in the shaft, which makes the bridge tilt and causes uneven pad wear.

What does the return spring do?

When the brake pedal is released, air pressure in the chamber drops, but a separate force is still needed to return the camshaft and bridge plate to their starting position — this is the return spring's job. The spring guarantees that a narrow but measurable running clearance forms between the pad and the disc. Without this clearance, the pad would stay in constant contact with the disc; a dragging pad heats up, increases fuel consumption, and wears out prematurely.

How does the adjuster gear assembly (automatic adjuster mechanism) work?

The pad wears a tiny amount with every brake application; if this wear is not compensated, the running clearance gradually grows, pedal travel lengthens, and brake response is delayed. The adjuster gear assembly is a clutch-gear or worm gear mechanism integrated into the camshaft; whenever the running clearance exceeds the defined limit during a brake application, the mechanism advances one increment, turning the adjusting screw and keeping the pad-to-disc clearance constant. This automatic adjustment means the driver feels the same pedal travel and the same brake response throughout the pad's service life, eliminating the need for manual adjustment.

Components of the caliper mechanism and their function

Component	Function	Symptom when worn
Camshaft (eccentric shaft)	Transmits rotating motion from the chamber to the bridge as a linear push	Wear on the eccentric profile, uneven pad pressure
Thrust bearings	Support the camshaft and bridge with low friction	Radial play, ticking/knocking noise, increased heat
Bridge plate	Transfers motion received from the camshaft to the adjuster gear assembly	Tilted seating, one-sided pad wear
Return spring	Returns the assembly to its starting position when the brake is released	Pad dragging, constant light contact
Adjuster gear assembly	Automatically keeps running clearance constant as the pad wears	Longer pedal travel, delayed brake response
Dust boots / seals	Protect the camshaft and bridge from dirt, moisture, and salt	Internal corrosion, mechanism sticking

What is the difference between the caliper mechanism and the drum brake slack adjuster?

In drum brakes, automatic adjustment is performed by a separate external arm mechanism (the slack adjuster); the chamber's pushrod moves this arm from outside, and the arm can be observed visually. In disc brakes, by contrast, the adjuster mechanism is a sealed gear-clutch system inside the caliper housing, integrated into the camshaft — it is not visible from outside and cannot be observed directly without removing the caliper. This difference also changes the diagnostic method: on a drum brake the arm's movement angle is checked visually or by measurement, while on a disc brake diagnosis is done indirectly, through brake pedal travel, the play felt when the wheel is turned by hand, and pad thickness measurement.

The caliper mechanism is a direct part of the braking force chain. A fault in the camshaft, bearings, or adjuster gear assembly causes one wheel to brake less, or later, than the others, increasing the risk of pulling to one side or vehicle instability. If vibration, a ticking noise, or a dragging pad is noticed, the vehicle should be inspected promptly.

Standards and further reading

This subject is governed by the equipment rules for air-braked commercial vehicles. In the United States the federal air brake standard, FMVSS 121 (49 CFR 571.121) defines the reservoirs, protection and timing a compliant system must provide, and Europe applies the equivalent limits of UNECE Regulation No. 13. For further detail, see the illustrated reference guide at airbrakecompressor.com. Always confirm specific figures against the current regulation and the vehicle manufacturer service data.

Outside the United States the equivalent duties sit in national law. In the United Kingdom, regulation 18 of the Road Vehicles (Construction and Use) Regulations 1986 requires every part of the braking system to be maintained in good working order. In Canada, air brake systems fall under the Motor Vehicle Safety Regulations, which contain CMVSS 121.

How is a caliper mechanism fault recognised?

A caliper mechanism fault is often mistaken for a simple pad problem, because the first symptom usually shows up on the pad — uneven wear, dragging, or squealing. But if the same symptom returns after the pad has been renewed, the problem lies in the mechanism itself. The main symptoms encountered in the field and how to check for them are as follows:

Caliper mechanism fault symptoms and how to check them

Symptom	Probable cause	Check / verification
Disc/rim gets excessively hot after braking, pad is dragging	Return spring broken or weakened, or the adjuster gear assembly has over-advanced	Turn the wheel by hand and feel for constant drag, visually inspect the spring
Rhythmic ticking/knocking noise during braking or wheel rotation	Wear and radial play in the camshaft bearings	Without removing the caliper, grip the bridge by hand and check for radial play

Symptom	Probable cause	Check / verification
Brake pedal becomes stiffer over time or travel lengthens	Adjuster gear assembly is not tracking pad wear, mechanism is sticking	Measure the pad-to-disc running clearance, test the freedom of movement of the adjuster mechanism
Vehicle pulls to one side under braking	One of the two calipers on an axle produces less force than the other	Compare the pad contact pattern and colour uniformity of both calipers on the same axle
Visible play in the bridge plate, guide bolts loose	Play has grown in the bridge axis due to bearing wear	Push the bridge by hand and check the amount of free play
Pad wears unevenly, one edge noticeably thinner than the other	Camshaft or bridge is moving at an angle, bearing wear is asymmetric	Compare pad thickness at both ends with a micrometre or caliper gauge
No advancing sound/feel from the adjuster mechanism	Adjuster gear assembly has rusted or become fouled and is seized	Turn the adjuster mechanism by hand with a suitable tool and check for resistance and a clicking feel

How is play (clearance) in the caliper mechanism checked?

The check begins with the wheel on the ground: the park brake is released, the wheel is turned by hand, and an even, light drag is expected throughout the full rotation. A noticeably increased resistance at one point, or a periodic "tick" felt, points to a fault in the camshaft bearings or the bridge seating surface. The second step is a manual check of the bridge plate; light sideways force is applied to the bridge, either through the dust boot or with the caliper open, and any perceptible play indicates that bearing clearance has grown.

The third step is measuring the pad-to-disc running clearance; this measurement shows whether the adjuster gear assembly is doing its job. If the clearance is above the vehicle's defined range, the adjuster mechanism is not advancing — usually because of corrosion, fouling, or gear wear. If there is no clearance, or the pad is in constant light contact, the return spring or an over-advanced adjuster mechanism should be investigated. In both cases, the final diagnosis is confirmed only by removing the caliper and visually inspecting the mechanism.

The drag felt at the wheel does not always come from the mechanism; to check separately whether the caliper still slides freely on its carrier, see the caliper guide pin, bushing and bolt guide.

Before replacing a caliper as "faulty," always check the return spring and the freedom of movement of the adjuster mechanism. In a significant share of calipers replaced in the field, the real problem is a single spring or a rusted adjuster gear; even after the whole caliper is replaced, the root cause remains unaddressed and the same symptom can reappear on another axle.

How is the caliper mechanism replaced? Step by step

1. Park the vehicle on level, solid ground, apply the park brake, place wheel chocks, and switch off the engine.

2. Release the air pressure on the relevant axle according to the system instructions; the chamber or air line connection must never be loosened before pressure has been vented.
3. Remove the wheel, take out the pads, and detach the caliper from the carrier; support the caliper so that hoses and cables are not left under tension.
4. Disconnect the brake chamber from the caliper and move the caliper housing to the workbench.
5. Remove the dust boots and seals; carefully take the bridge plate and the adjuster gear assembly out of the housing.
6. Remove the camshaft together with its bearings from the housing; take care that the bearing needles or rollers are not lost during removal.
7. Clean the inner surfaces of the housing, the camshaft bearing seat, and the bridge sliding surfaces; remove old grease and wear debris, and visually inspect the eccentric profile and bearing surfaces for signs of wear.
8. Lubricate the repair kit — containing the new camshaft, bearings, return spring, and adjuster gear assembly — with the high-temperature assembly grease specified by the manufacturer.
9. Fit the components in the reverse order of removal: camshaft, bearings, bridge plate, adjuster gear assembly, return spring, then the dust boots and seals.
10. Seat the caliper on the carrier, grease the guide pins, and tighten the bolts in a crosswise, staged sequence; **torque values must be taken from the vehicle's current OE service manual**.
11. Connect the chamber, fit the pads, mount the wheel, restore air pressure, and press the brake pedal a few times to confirm that the adjuster gear assembly automatically sets the running clearance and that the wheel turns freely.

Points of caution: common mistakes

- **Trying to replace bearings one at a time:** The caliper mechanism is designed as a set; replacing a single part leads to dimensional and tolerance mismatches.
- **Fitting new pads without resetting the adjuster mechanism:** The running clearance is left uncalculated, and on first use the pedal feels either too stiff or too soft.
- **Using the wrong type of grease:** Grease not rated for high temperature melts or runs out quickly; the bearing is left dry and wears rapidly.
- **Reusing the dust boot or seal:** A torn or hardened boot lets in moisture and dirt, accelerating corrosion inside the mechanism.
- **Tightening the guide bolts to full torque in one go:** Without a crosswise, staged tightening sequence, the bridge seats at an angle and the pad wears unevenly.

- **Forcing the camshaft into place with a hammer:** Impact permanently damages the eccentric profile and the bearing seat; the shaft must always be seated by hand or with a suitable tool.
- **Choosing a part by brand:** The correct repair kit is selected using the OE reference number stamped on the caliper and the vehicle's engine/chassis code, not by brand name.
- **Starting disassembly before pressure is vented:** Uncontrolled release of an air- or spring-loaded component can cause serious injury.

Technical values and check points

The table below summarises the main points checked in the field on the caliper mechanism and their general reference ranges. Values vary by vehicle manufacturer, caliper model, and system; **the exact value must always be taken from the vehicle's current OE service manual**.

Caliper mechanism check points (general reference)

Check point	General reference	What deviation indicates
Pad-to-disc running clearance	A narrow gap with no perceptible drag when the brake is released (OE value is authoritative)	Too large lengthens pedal travel; too small or absent causes dragging
Camshaft radial play	Too small to be felt by hand (OE tolerance is authoritative)	Perceptible play indicates worn bearings
Adjuster gear assembly advancing behaviour	Small, incremental advance whenever needed on each brake application	No advance indicates the mechanism is sticking or seized
Return spring tension	Force sufficient to return the bridge and camshaft fully to their starting position	If weak, the pad continues to contact the disc
Guide pin / bridge bolt torque	Value defined in the vehicle's OE service manual, crosswise staged tightening	Too low causes loosening and vibration; too high causes housing deformation
Assembly grease type	Manufacturer-approved special grease resistant to high temperature and water	Wrong grease causes premature drying out or running
Dust boot / seal integrity	No tears, fully seated in place	If torn, dirt and moisture enter and internal corrosion begins
Pad wear symmetry	Similar thickness between the two pads and between both ends of each pad	A large difference indicates the mechanism is running tilted or unbalanced

Caliper mechanism components are part of the braking safety chain. When selecting the camshaft, bearing set, return spring, and adjuster gear assembly, exact match to the vehicle manufacturer's OE reference must be required. A camshaft with a different geometry, or a spring with a different stiffness, disrupts pad pressure and automatic adjustment even if the caliper appears to work visually.

Caliper mechanism maintenance and service life

The single strongest factor determining the caliper mechanism's service life is the integrity of the dust boots and seals. During periodic maintenance, dust boots should be visually checked for tears, hardening, or poor seating, and fouled boots should be replaced; moisture and salt that get inside the mechanism corrode the camshaft and bearings within a short time. Every time the pads are changed, the freedom of movement of the adjuster gear assembly and the tension of the return spring should also be checked — these two components are not replaced as often as the pads, but they should be checked just as often.

High-pressure washing is a particular risk for the caliper mechanism. When a water jet is aimed directly at the dust boot or the bridge area, water can enter past the boot's edge; this is not apparent at the time, and shows up days later as corrosion and stiffness. For fleets operating in salty, wet winter road conditions, periodically checking the caliper mechanism visually and by hand without removal — bridge play, adjuster mechanism resistance, spring tension — is the cheapest way to catch a fault before it causes a breakdown on the road.

Fleet operators are advised to add a caliper mechanism check alongside pad thickness measurement in their periodic maintenance plan. Sticking in the adjuster gear assembly or early bearing wear can begin even while the pad is still above its limit value; catching these early signs significantly reduces the risk of sudden pad dragging or one-sided brake loss out on the road.

VADEN ORIGINAL caliper mechanism components

VADEN ORIGINAL manufactures camshafts, bearing sets, return springs, adjuster gear assemblies, and the complete repair kits that combine them, to OE dimensions and tolerances, for heavy commercial vehicle air disc brake calipers. The product range covers the caliper housing types and mounting geometries commonly used in truck, tractor unit, bus, and trailer applications.

To find the correct repair kit, using the OE reference number on the caliper housing and the vehicle's engine/chassis code, rather than the vehicle's make and model, **removes the risk of a wrong match**. The caliper mechanism is the final link — and the one that actually generates braking force — in a chain that starts with the compressor drying the air in the brake system; if an earlier link in that chain (air dryer, relay valve, brake chamber) has a problem, brake performance is affected even if the caliper mechanism itself is sound. The VADEN technical guide library includes separate fault, replacement, and maintenance guides for the air compressor, air dryer, relay valve, brake chamber, ABS sensor, and brake pad.