Iron Caliper Brake Kit
Engineering Test Summary
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Introduction

Alcon Components Limited have used their Defence braking experience to develop a brake kit for the armoured Toyota Landcruiser LC200.

SG iron was chosen for the brake caliper housings to provide the maximum strength for robustness, durability and corrosion resistance. The stronger material also allows the caliper profile to be optimised allowing the kit to package within smaller wheel profiles than can be achieved with aluminium calipers kit.

Alcon have carried out a complete technical sign-off for the brake kit. This includes:

• Theoretical brake system calculations
• Finite Element Analysis
• Simulation bench test work
• On-vehicle test work

The brake kit has been TUV approved at 5800kg

This document is a summary of the brake sign-off carried out for the brake kit.
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Theoretical brake system calculations

The first stage of introducing a brake system is to create a technical specification. Alcon’s Engineers use vehicle data to create a system that will meet both legislative requirements and Alcon’s targets for brake performance.

The calculations indicated acceptable results for:

• Full system brake performance, half system brake performance and servo failed performance for a passenger car (M1 class), minibus (M2 class) and light commercial vehicle (N2) at 5800kg to ECE 13 and 13H. This is shown by results for pedal efforts required for given levels of deceleration in each condition.

• Brake balance. Ensuring the system will not cause instability through the sizing of front and rear brakes.

• Fluid capacity. Calculations ensure that there is sufficient fluid capacity in the standard LC200 master cylinder for use with the Alcon kit in all conditions.

• Thermal capacity. Calculations ensure that the brake discs have sufficient thermal capacity not to have fade issues.

• Work rates. Ensuring that the brake pads are of an adequate size for work. This reduces pad wear and fade.

• Stability control systems. The calculations are used to size the brake kit to give minimal affect upon the standard LC200 stability control systems without the requirement for re-tuning.
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Finite Element Analysis

FEA is used to as part of the design process.

The calipers, mounting brackets and discs had simulations carried out to ensure that their performance met Alcon’s targets for:-

• Caliper physical strength. The brake calipers do not have issues with combinations of high pressures and torque calculated at over-load conditions. Elevated temperatures were also added to the analyses.

• Caliper fatigue. The brake calipers have performed simulated fatigue cycles without concern.

• Caliper deflection and displacement. Simulations showed the levels of deflection during applications as well as the amount of fluid required for high pressure applications. This ensures that the calipers will not use more fluid than is available in the system and that pedal feel will not be compromised.

• Disc strength and fatigue. The discs completed various simulations combining overload conditions of brake torque and temperature ensuring strength and crack resistance.

• Disc displacement and coning. Simulations show the amount for deflection and coning seen in the disc during temperature cycles. The discs met Alcon’s targets to ensure that pads will remain in full contact with the disc and drag will not be caused through disc movement.
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Caliper Bench Test

Physical tests were used to validate results from the systems calculations and FEA. Caliper tests are broken down into four areas:-

- **Measurement**

  Calipers were measured to ensure that they met Alcon’s targets for:-

  - Fluid capacity
  - Physical deflection
  - Piston sliding pressure
  - Piston fallback
  - Knock-back
  - Residual drag.

  These measurements ensure that the caliper will physically perform as intended during the design process. Multiple samples were tested to give confidence that all product met the test criteria.

- **Strength**

  Calipers were tested to ensure adequate physical strength. Extreme overload conditions are used

  - Static strength – calipers did not fail when subjected to up to 600 bar pressure.
  - Mounting strength – calipers were subjected to the torque that would be see at 1.75 x a 0.83g deceleration.
  - Bleed and connector port strength – calipers had fittings over-torqued to ensure strength in hydraulic ports.

  All samples exceeded the requirements of the test criteria
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Caliper Bench Test (continued)

• Endurance

Calipers were tested for fatigue using Alcon’s accelerated fatigue procedures:

• Hot pressure endurance – calipers were fatigue tested at high temperature.

• Pressure endurance with thermal cycle – calipers were fatigue tested at varying temperatures from extreme cold to extreme heat.

• Pressure and drag fatigue – calipers were tested to simulate extreme cycles with the combined torque and pressure for a high deceleration.

All samples exceeded the requirements of the test criteria

• Environmental

• Salt spray – calipers were hydraulically cycled in a salt spray chamber.

• Dirt excluder – calipers were submerged in a solution simulating salt and mud slurry. Calipers alternated between static and being cycled hydraulically.

• Aging stability – calipers were tested to ensure that there are no issues with the piston and seal interface at elevated temperatures and humidity.

All samples exceeded the requirements of the test criteria
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Dynamometer Test

Calipers discs and pads were tested on one of Alcon’s brake dynamometers.

- Friction performance – full AK Master tests were carried out to measure friction performance in various standard conditions. Results from this were compared with figures for friction used in the full system calculations to ensure that the physical performance will be in line with the theoretical.

- Strength – multiple samples of discs endured Alcon’s standard disc strength test cycles for high torque simulating high deceleration events.

- Endurance – Alcon have an endurance cycle that has been specifically designed to simulate conditions that will create disc cracking. Multiple samples of discs endured the tests.

- Deflection – Discs endured friction cycles designed to push the discs into high temperatures to enable the disc to be measured for deflection. This was then compared to Alcon’s standards and the results from FEA.

Discs, pads and calipers all met the requirements of the tests and were in line with system calculations and FEA.
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Vehicle Test

Alcon Engineers instrumented a vehicle and carried out tests with the standard brake system, the front only brake kit and the full brake kit. This was done at various vehicle weights from 4500kg to 5800kg.

Tests were carried out in line with ECE13 and 13H requirements. This included:

- Full system testing
- Testing with front brakes only
- Testing with rear brakes only
- Testing without servo (booster) assistance

The results were in line with the initial theoretical system calculations.

As a result of the testing and calculations Alcon recommend that:

- A front only kit is used on vehicles up to 4500kg in armoured weight
- A full kit is used on vehicles between 4500kg and 5800kg

Results indicated spare capacity with the potential to run at higher weights. This was not validated due to the limits of the test vehicle used.

The test vehicle was then used to obtain a TUV certification the full kit at 5800kg.
Alcon Components Limited
Apollo
Tamworth
Staffordshire B79 7TN
England
Phone: +44 (0)1827 723700
Fax: +44 (0)1827 723701

www.alcon.co.uk