AFTERMARKET OFFSET BRAKE BOOSTER ASSEMBLIES

Introduction

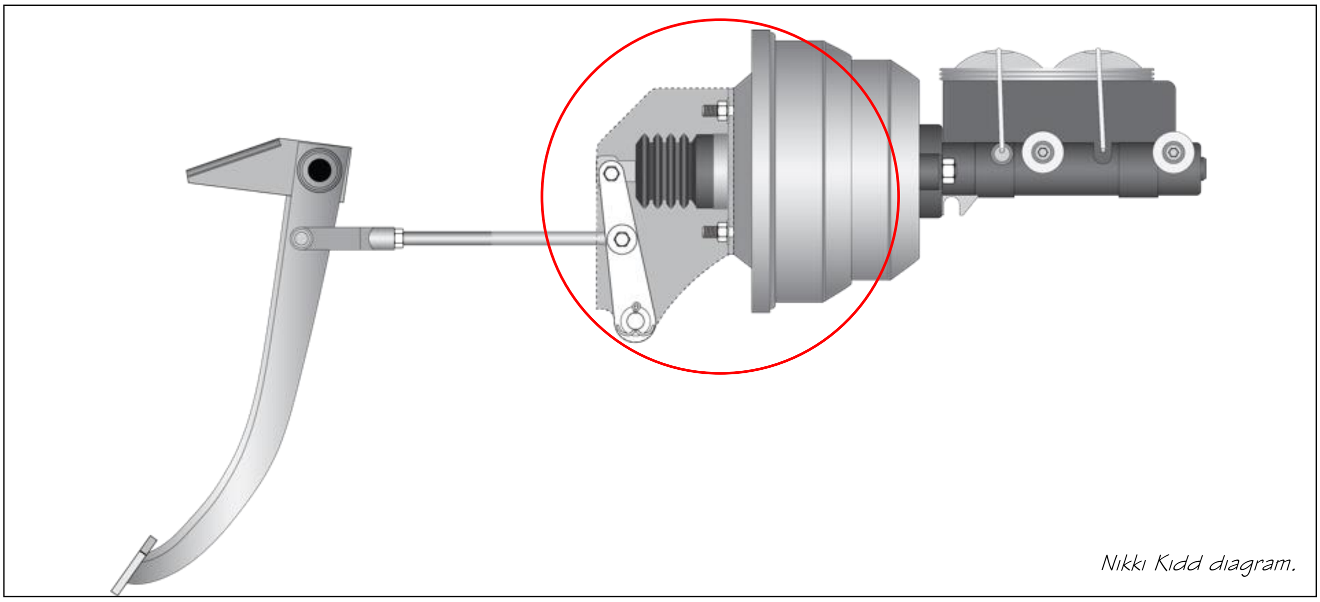


Diagram 1.

Purpose

This Information Sheet has been developed to provide:

- a set of safety-based requirements for the LVV certification of common aftermarket offset brake booster assemblies; and
- notice that assemblies which fall within the scope of this Information Sheet can be assessed and LVV certified by any 1A-category LVV Certifier, without the need for an individual approval in writing by the LVVTA Technical Advisory Committee (TAC), as required by 8.3.4(c) of 'Chapter 8 - Braking Systems' of the New Zealand Car Construction Manual (NZCCM).

Background

An offset brake booster bracket can be used to allow installation of a brake booster to a vehicle with space constraints within the engine compartment (which is usually due to a wide V8 engine). This is achieved by way of an offset crank inter-positioned between the brake pedal push-rod and booster, supported within a steel bracket. The offset crank consists of two pieces of flat steel plate, with the push-rods sandwiched between them, creating a robust and fail-safe double-shear attachment. Brake pedal pressure is transmitted by the vehicle's original brake pedal to the offset crank, which then transfers the load to the brake booster or master cylinder, via a second push-rod. Assemblies are produced by various aftermarket manufacturers and resemble original equipment (OEM) units used in 1950s-onwards General Motors, Ford, AMC, and Chrysler passenger cars. The TAC has assessed some of the readily available assemblies, and identified several issues that required rectification to bring them up to an acceptable standard for safe road use in New Zealand.

Various Sections to Deal with the Issues

The issues have been compiled into various sections within this Information Sheet, and while not all assemblies will have every issue covered here, due to the number of subtle design differences available all should be checked and compared in every case. The sections are listed below in quick-link format. Note that while some inspection can usually take place in-situ, the assembly may need to be removed from the vehicle, with partial or full disassembly of components to enable a thorough inspection by the LVV Certifier.

1. Scope of Information Sheet

Within Scope

Assemblies are available under numerous brand-names in various configurations and offsets. For an assembly to be assessed and approved using this Information Sheet, it must fall within the scope, i.e., assemblies must incorporate ***all*** of the following good-practise design features:

- produced by an aftermarket braking system component manufacturer;
- heavily-constructed dual-sided bracket design, with integral booster/firewall mounting flanges, inter-positioned between the firewall mount and brake booster, similar to those depicted in the photographs below;
- an offset crank to transmit the braking loads, that has a pair of steel plates sandwiching the push-rod ends between them;
- be within the maximum parameters of (as shown in the Diagram 2):
  - maximum 120 mm offset from the firewall mount to the booster mount measured horizontally; and
  - maximum of 155 mm from the pivot shaft to the output push-rod on the offset crank measured vertically between centres.

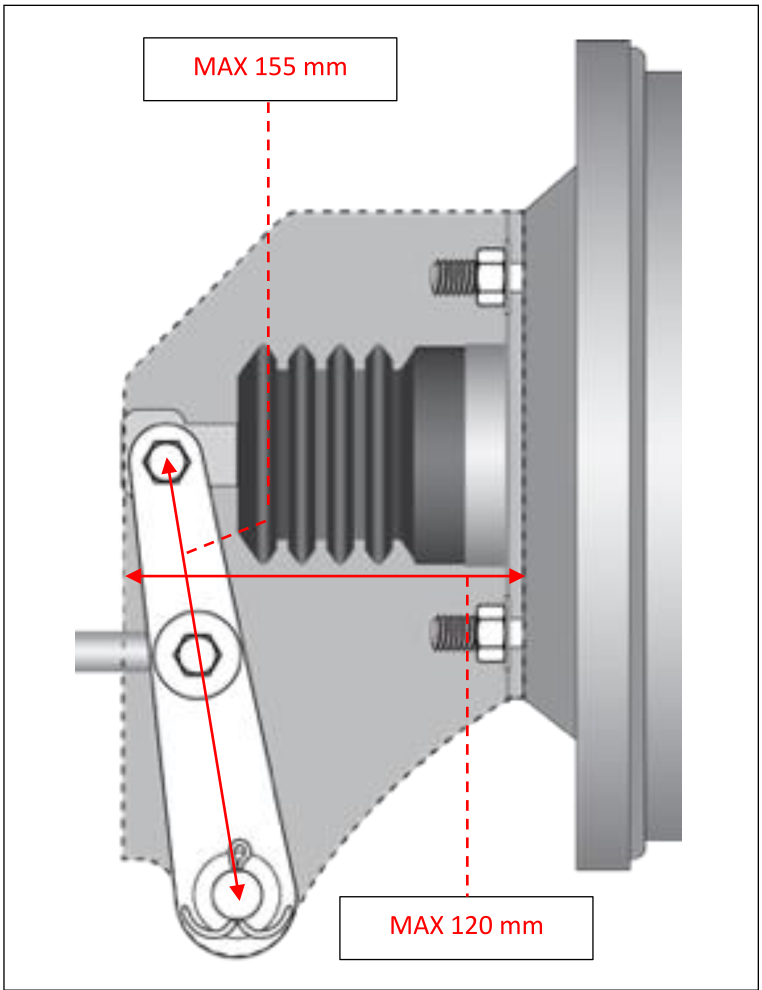


Diagram 2: *This illustration demonstrates the parameters as stated in point 4.*



Above left and right: *An OEM assembly from a Ford Mustang, with an aftermarket 'reproduction' version shown on the right.*

Left: *Example of a typical assembly intended to be covered by this Information Sheet – this is an MP Brakes version.*

<u>Out of Scope</u>

Custom or one-off offset crank brake booster assemblies, assemblies that are not fail-safe, do not incorporate a pair of offset cranks, or which differ in principle to those covered in this Information Sheet. These out-of-scope assemblies must be individually approved in writing by the TAC via the Build Approval Process, as required by 8.3.4(c) of 'Chapter 8 - Braking Systems'.

2. Minimum Material Specifications and Guidelines

Each assembly will require a full and detailed assessment by the LVV Certifier in every case to ensure that it is within the scope of this Information Sheet, that it meets the minimum technical requirements and intent of this Information Sheet, and that it meets all other applicable LVV requirements. The following should be used as a guideline for the minimum dimensions and specifications of the main parts.

Note that while metric sizes are listed, equivalent imperial sizes are acceptable. For example, 3/8" (inch) is considered equivalent to 10 mm.

Bracket side plates (steel):	3 mm.
Offset crank (steel):	3 mm to 5 mm each dependant on length and shape.
Push-rods (steel):	6 mm to 8 mm flat, or 8 to 10 mm threaded rod/round, dependent on length and shape.
Pivot shaft (steel):	10 mm shank diameter anti-rotational pivot shaft.
Maximum offset (as shown in Diagram 2):	• 120 mm offset measured horizontally from the firewall mount to the booster mount; and • 155 mm offset measured on the offset crank between the pivot tube and output push-rod centres.

3. Pivot Shafts

Securing of Pivot Shafts

The Problem

It's common for aftermarket assemblies to use a bolt and nyloc nut to secure the pivot shaft of the crank to the bracket. However, in most cases there is no crush-tube inside the pivot shaft, and the bolts generally don't have a step for the nut to tighten against. Therefore the pivot shaft is relying solely on the friction of the nylon section of the nyloc nut, rather than the torque of the fasteners. This is poor engineering practice, especially in a critical braking component. The nyloc part of a nut should only be relied upon as a secondary method of preventing a fastener from completely disengaging and shouldn't be depended on as a sole means of attachment for a critical component. The lack of a step or crush-tube also means the nut and bolt could be unintentionally over-tightened causing the assembly to bind or jam, and preventing the pedal from returning fully to its stop, or holding the pedal down against the floor. Either of these situations will result in an inoperative braking system.

Requirements

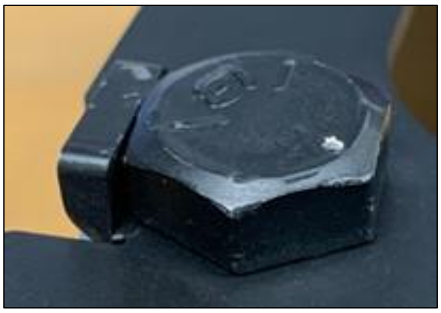
- Option one is to use a correctly machined shoulder-bolt with a nyloc nut that can be correctly torqued up without introducing any bind.
- Option two is to:
  - modify the existing bolt by shortening it and drilling a hole through the end for a linch-pin, split-pin or r-clip (see example pictured right); and
  - allow enough space for some end-float to ensure no binding occurs; and
  - where possible, incorporate a hardened steel flat washer/shim to hold the clip away from the bracket and allow for a small amount of end-float adjustment; and
  - ensure the hole for the linch-pin, split-pin or r-clip is no larger than one third of the shank diameter and drilled centrally through the shaft to ensure it is not weakened; and
  - use a good quality automotive linch-pin, split-pin or r-clip.
- Option three is to use a pin or a bolt, with a machined groove and an automotive circlip or e-clip, and employing the same applicable safeguards as specified for Option two.

Anti-rotation of Pivot Shafts

The Problem

To replicate OEM examples, pivot shafts must be prevented from rotating, to avoid harmonics, rattles, vibrations, and premature wear.

Requirements



- Option one is to weld or bolt a small tab to the bracket which locates against a 'flat' on the bolt head, or a 'flat' that has been machined into the head of a clevis pin.
- Option two can be applied where the bracket has a suitably strong area (and provided no reduction in strength occurs as a result), which can enable a section to be cut and bent to create a tab that sits against a 'flat' on the bolt head or a machined 'flat' on the head of a clevis pin (see example pictured right).

4. Pivot Tubes and Spacers

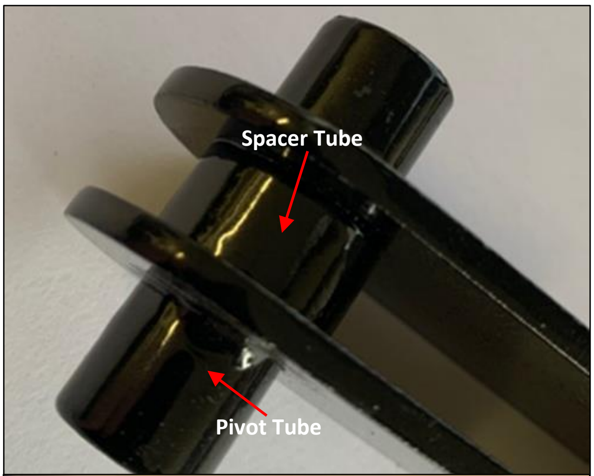
Pivot Tubes

The Problem

TAC members have found the pivot assemblies in some OEM units do not contain any bushes, meaning the pivot shaft and tube run metal-on-metal. Therefore, despite not being ideal, it is acceptable that an aftermarket unit doesn't require a bushing, provided there is adequate surface contact between the shank of the bolt or pin and the pivot tube, rather than threaded sections, which will tend to wear more quickly.

Requirements

- The pivot tube must be a snug fit over the pivot shaft, and there should be no binding, no excess 'slop', and there should only be a small amount of end-float or free-play.
- The pivot tube must not be able to be clamped in any way between the side-plates which causes a bind situation.
- The pivot tube or spacers used to position and support the offset crank must be made from steel. If fitted, plastic spacers must be removed and replaced with correctly sized steel equivalents.



Optional Improvements

The following optional improvements are not requirements, but are worth considering:

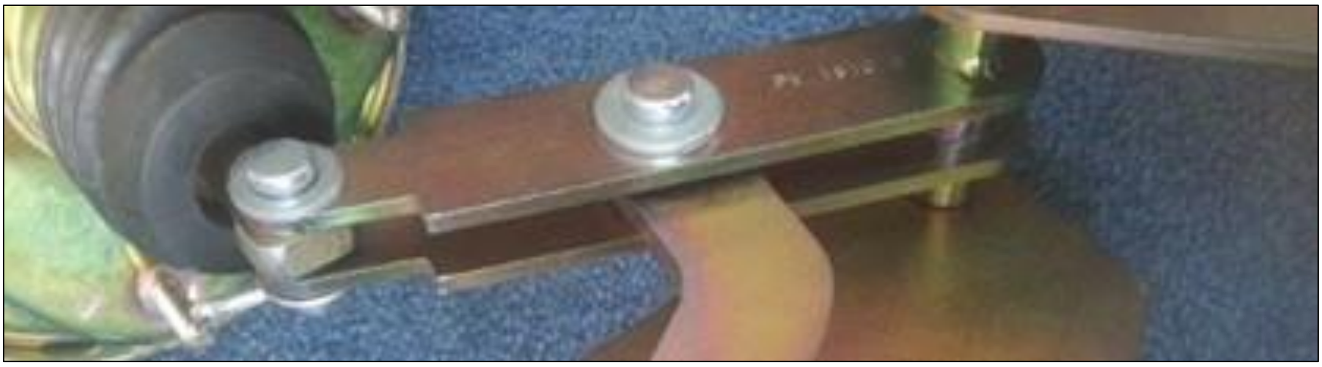
- The addition of a bronze, 'Delrin', or self-lubricating nylon bushing, along with side-thrust washers (see example picture at right), is a highly recommended improvement. However, to do so may require some re-design of the pivot assembly and related components, as the addition of bushings will require larger physical dimensions of some of the components. If you are contemplating this upgrade, you should seek input from your LVV Certifier before making any changes.
- A lubrication fitting (i.e., a grease nipple or 'zerk' fitting) is a simple addition that will prolong the life of the component, reduce the chance of squeaks or rattles, and is a highly recommended improvement. However, keep in mind that a grease fitting in this location can also be difficult to access, and installation should in no way interfere with the operation of the assembly, or affect its strength.

Pivot Spacers

Pivot assemblies use spacers to separate and maintain the correct distance and position between the offset cranks. The pivot tube and spacers keep the offset crank properly aligned, straight, and operating smoothly, so it is important this part of the assembly is well designed, and uses components that are fit for purpose and which feature a fail-safe design. There are a number of different pivot tube designs used, but each needs to be assessed on a case-by-case basis.

5. Offset Crank Design and Construction

The offset crank assembly consists of a pair of steel plates, separated by the push-rod end-fittings, that create a strong, reliable, and fail-safe double-shear attachment system.



Requirements

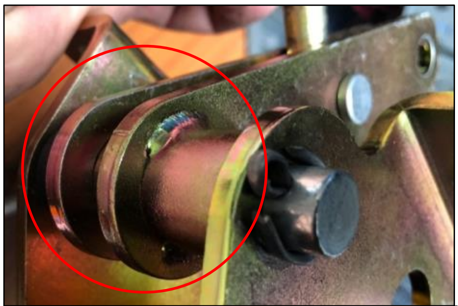
- Each plate incorporated in the offset crank assembly must be made from a single piece, and be a minimum of 3 mm thick steel plate (giving a combined 6 mm crank thickness).
- The offset crank levers must always be fail-safe in their design; in other words, upon the failure of any attaching weld, the brake pedal must continue to actuate the master cylinder via the offset crank. Because of the fail-safe nature of the assembly and the lack of any side-loadings (like there might be in a brake pedal assembly) the attaching welds of the crank lever-to-spacer tubes are less critical, meaning they don't need to be fully welded, and don't need a non-destructive test (NDT).

6. Welding

Requirements

In almost all cases where components within a braking system are welded, the applicable LVV requirements state the welding method must be TIG only, and those welds must pass a non-destructive test (NDT). In the case of assemblies that are covered by this Information Sheet however, some relaxations have been facilitated, but only provided specific criteria is met in each case.

- It is common for these assemblies to have just two stich-welds per side, connecting the offset cranks to the pivot shaft assembly. As there are no side-loads present these are only locating welds, and do not carry any load. Therefore, these welds do not have to be TIG welds, and do not require NDT testing, *provided* the LVV Certifier carries out a *thorough visual examination* of the welds, and confirms they are free from any visual defects, and are of high tradesman-like quality. Defects would include under-cut, lack of fusion, porosity, or cracks.
- These relaxations relate only to the parts detailed, and no further relaxations apply. All other welds must meet applicable technical requirements.



Above: *Example of a dual-lever setup with a fail-safe connection to the pivot shaft.*

**Fail-safe means the attachment of the offset cranks to the pivot tube is designed so that upon failure of the attaching weld, the offset crank will still reliably and safely actuate the master cylinder.*

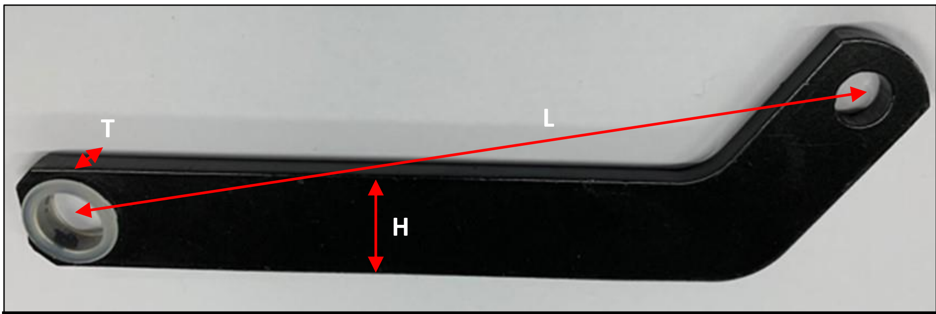
7. Push-rods and Rod-end Joints/Clevises

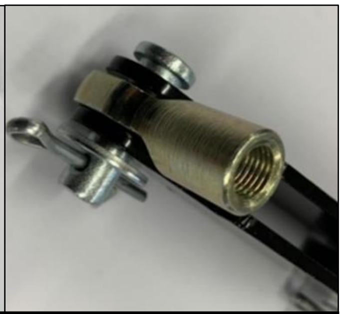
Some push-rods in aftermarket assemblies incorporate welds, usually for the attachment of end-fittings.

Requirements

- These welds cannot be approved, and welded push-rods will need to be replaced with compliant one-piece parts.

- Some push-rods are made from flat plate rather than round or threaded rod and may have a curved 'hockey-stick' shape, like the one pictured. The push-rod plate must have enough height, as well as thickness, to be able to resist all loads. The TAC has found some clevis joints on these units to be very loose-fitting within their corresponding holes. This free-play causes excessive movement at the brake pedal and brake system, which will worsen over time. It is most likely a mis-match of imperial-clevises being used in metric holes (or vice-versa).





Left: *Typically, a 6.5mm thick (T) and 170mm long (L) push-rod such as the one shown above will be 25mm high (H).*
Right: *Clevis*

- Only correctly sized, snug-fitting clevises must be used, and LVV Certifiers will need to check for correct fitment of pins, and that no joints or connections have excessive free-play.
- If used, spherical-bearing rod-ends must be automotive-style, of a suitable size and quality, and can be either greaseable (if accessible), or self-lubricating.

8. Brackets

The brackets used to reposition the booster must be strong enough to resist braking loads, support the pivot shaft and tube, and adequately support the weight of the brake booster and master cylinder. These brackets are typically a pair of folded plates made from 3 mm steel.

9. Firewall

Attention needs to be paid to vehicle structure attachment. Installing an offset booster with an OEM brake pedal can alter the effective brake pedal ratio, which can change the amount of pedal pressure required to activate the brakes, and/or effectiveness of the brakes. If greater pedal pressure is required to apply the brakes, the pedal-box and firewall will also be subjected to greater loads, which can result in flexing, bending or longer-term cracking and fatigue related failures, if not suitably reinforced. Some firewalls may require additional strengthening, load-spreading plates, or bracing back to the dashboard or dash-bar, to better support the brake assembly. Testing for flex should include pedal-loading simulating hard braking, and a side-loading, usually by loading the assembly by hand.

The LVV Certifier must ensure all aspects of the assembly and installation are fit for purpose and all applicable LVVTA Braking System requirements are met.

Not all assemblies will come with a firewall seal, resulting in a large hole between the footwell and engine bay. A suitable seal must be installed to prevent exhaust gases, vapour, and liquids from entering the passenger compartment, and to meet the applicable requirement contained in NZCCM Chapter 9 (Engine and Drivetrain Conversions) 9.4.4 (Engine compartment and floor modifications).

10. Brake Pedal Ratios

When adding an offset booster bracket, the brake pedal ratio needs to be calculated as a combined ratio of both the pedal, and the crank. This combined ratio is used to make a comparison with the LVVTA brake pedal ratio requirements.

Getting the combined ratio into the correct range will ensure loads on individual components, attachments, and structures do not become excessive. This will result in brake input loads similar to OE, and a system that will still allow a vehicle to be pulled up, should the booster have its vacuum supply cut. It will also mean there's less likelihood of needing further braking system changes or modifications as a result (or unintended consequence) of this modification.

An offset booster assembly should not be used as a method of rectifying or correcting a significantly incorrect brake pedal ratio, however it can be used to effect minor changes.

The NZCCM provides a guide for a boosted brake setup ratio of no less than 4:1 and no more than 6:1. Some offset crank booster brackets will give ratios outside of these guidelines, and in such cases, the road-test is the over-arching test to determine whether the pedal ratio is suitable for LVV Certifiers, taking into account all of the braking system requirements.

See the formulas below (as shown in Diagram 3) to work out both the individual, and the combined ratios.

Note that when determining brake pedal ratios, you should always measure from centres, for example the pivot bolt centre, or the centre of the pedal pad.

Brake *pedal* ratio:

- A: Pedal pivot to pedal footplate = 300 mm
- B: Pedal pivot to push-rod = 50 mm
- Formula: A (300) divided by B (50) = 6 = ***6:1***

Offset *Crank* ratio:

- C: Crank pivot to booster push-rod attachment = 100 mm
- D: Crank pivot to pedal push-rod attachment = 70 mm
- Formula: C (100) divided by D (70) = 1.4 = ***1.4:1***

***Combined brake* pedal ratio**:

- Pedal ratio (***6***) divided by crank ratio (***1.4***) = ***4.2:1***

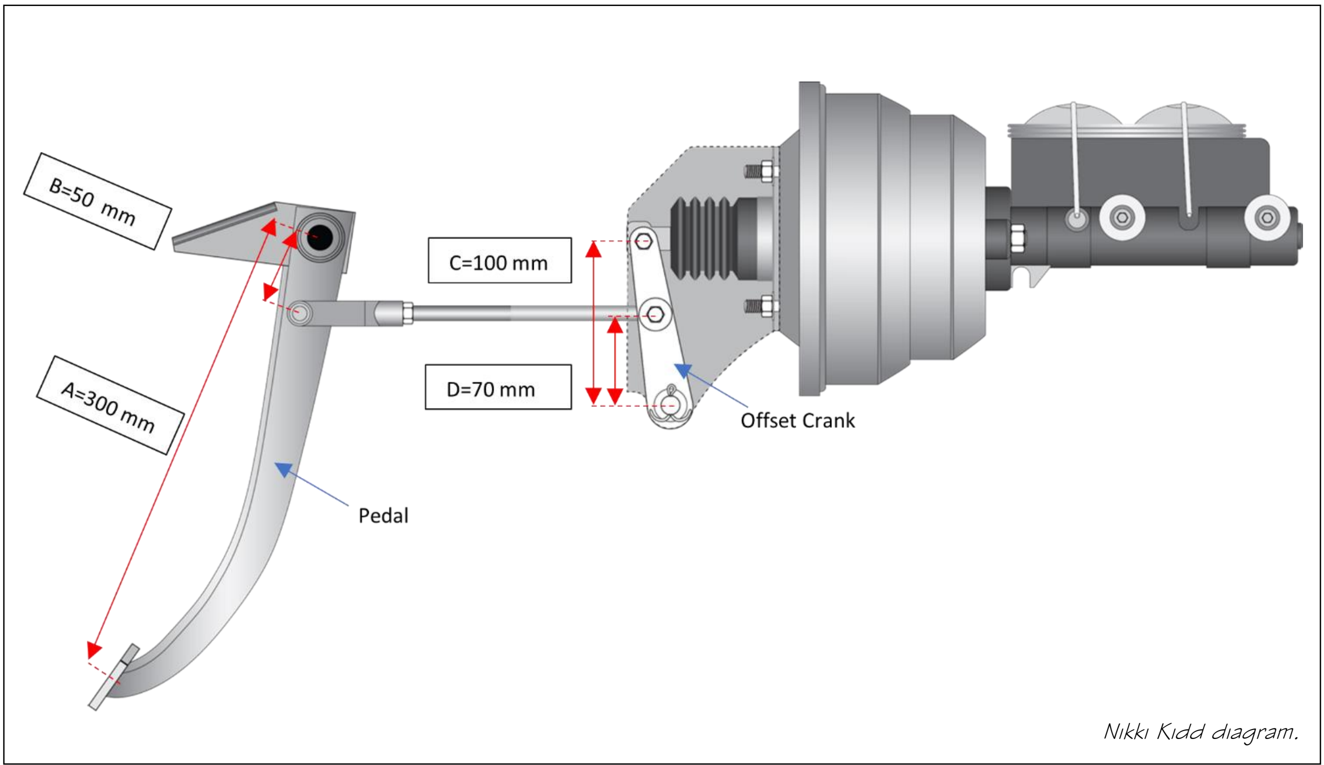


Diagram 3.

11. Hydraulic Brake Components and Systems

During the fitting of an offset brake booster assembly, some aspects specific to the modification itself, will also need to be considered. For example, if the vehicle's original single-circuit brake master cylinder is replaced, the requirements from the applicable section of the NZCCM must be applied, which would require the installation of a dual-circuit master cylinder. Likewise, if brake pipes are remanufactured, there will be requirements that cover the type of brake pipe you use, the flaring method, and the positioning of pipes in relation to high heat areas like exhaust pipes.

12. LVV Certification Requirements

- In every case, a vehicle which has been retrofitted with an offset booster bracket (or any other braking system modification that falls outside of the LVV Certification Thresholds) will require LVV certification.
- Where an aftermarket offset booster bracket is within the scope of this document, the LVV certification can be carried out by a 1A-category LVV Certifier.
- Where the LVV Certifier can verify that all aspects of the assembly and the overall modification meets the specifications and the intent of this Information Sheet, as well as meeting all other applicable LVV technical requirements, the modifications can be approved by the LVV Certifier without the need for any further input from the TAC.
- The LVV Certifier must always carry out a detailed inspection of the assembly and the vehicle. This may require the partial or full disassembly of components to enable a thorough inspection.
- As well as following the guidelines in the Information Sheet, all components, structures, attachment systems, brake performance, and any other aspects of the vehicle that may be affected by this modification, must be assessed to ensure that they meet the applicable LVV technical requirements contained in the NZCCM, and must be confirmed as being compliant, fit-for-purpose, and safe.

For further assistance with this Information Sheet, please contact your LVV Certifier, or LVVTA technical staff by emailing tech@lvvta.org.nz.

FOR FURTHER INFORMATION PLEASE CONTACT YOUR LVV CERTIFIER, OR LVVTA.