

# Rally Design

## DESIGNING YOUR 4-POT BRAKES KIT THE RALLY DESIGN-WILWOOD UNIVERSAL BRAKES SYSTEM



Invented by Rally Design, this system has enabled many low volume or one-off brake systems to be DIY manufactured which would not be economically viable by any other method.

The secret of producing an effective brakes kit is prior knowledge, good component selection and good machining facilities. However, it does require some technical knowledge, an experienced kit car builder or trained vehicle mechanic should have the ability.

In the past we have had to base the system on lug mounted Dynalite and lug mounted Superlite calipers which often experienced strut/upright to caliper lug fouling problems, also the design had to be 100% accurate, there was no room for error.

However, the new radial mount series, including Powerlite, Midilite, narrow bodied Superlite 4 and narrow bodied Superlite 6 offer design possibilities with much greater adjustment than is possible with lug mounted calipers. For example, if you have completed your design but wish to increase disc diameter from 240 to 260mm this is easily accommodated with the inclusion of 10mm spacers between the mount bracket and caliper.

### Prior knowledge

Even though your brake kit is a one-off, it may be possible that someone else has already utilised the Wilwood product to produce a kit similar to your requirements. Search through Locost forums or modifying marque forums, piston heads, etc or use Google to seek any useful information - Wilwood being a US product, the USA is often a valuable font of information.

**Lots of valuable information on [www.wilwood.com](http://www.wilwood.com)**

### COMPONENT SELECTION

The elements and design considerations of a brake kit are detailed below. **Caliper selection (all radial mount)**



**Powerlite 4-pot caliper** - the 'baby' of the Wilwood range but still very powerful, is normally used front and rear (see new Wilwood Powerlite handbrake caliper) on kit cars up to 700 kg, use with solid or vented disc up to 270mm diameter, should fit inside 13" wheels on a 260mm diameter disc, available (2) disc widths 10 and 21mm.



**Midilite 4-pot caliper** - fully dust sealed, the mid range caliper normally used on vehicles up to 1100kg, use with solid or vented disc 240 to 310mm. Works very well on a 280/285mm diameter disc inside most 14/15" wheels. Note available in (3) disc widths 10mm, 21mm and 25mm.



**'Narrow bodied' Superlite 4-pot caliper** - fully dust sealed, top range caliper to pull down the speed on the most powerful vehicles, used on M3s, Cosworths, big Audis etc. Will suit 300 to 355mm, normally on 16" plus wheels, available to suit 28 and 32mm disc widths.



**'Narrow bodied' Superlite 6-pot caliper** - is a direct replacement for the narrow bodied Superlite 4 but is used where a 6-pot choice is preferred to a dust sealed 4-pot (note space precludes use of dust seals on the 6-pot caliper). Usage and discs as per Superlite 4-pot.



### MASTER CYLINDER/HYDRAULIC CALCULATIONS

It is often difficult to change the vehicle master cylinder and whilst a balance bar pedal box gives greater control over vehicle brake balance, it is not always necessary to change the stock master cylinder - Wilwood has a big range of different caliper piston sizes so that you can select a caliper piston diameter close to the original vehicle caliper piston area.

To calculate piston area, use the formula  $3.142 \times r \times r \times \text{number of pistons}$ . For example, an M16 caliper (2-pot with 54mm pistons) has a total piston area  $3.142 \times 27 \times 27 \times 2 = 4581 \text{sq mm}$ . For example, a 4-pot Princess caliper (4-pot with 38mm pistons) has a total piston area  $3.142 \times 19 \times 19 \times 4 = 4537 \text{sq mm}$ . Note single pot slider calipers are calculated as 2-pot, so the Escort RS Turbo Series 2 with 60mm pistons has a total piston area  $3.142 \times 30 \times 30 \times 2 = 5655 \text{sq mm}$ .

It is usually preferable to select a total piston area slightly larger than the stock caliper total piston area. This will give slightly more power but with a slightly, but acceptable, longer foot pedal travel.

### TOTAL PISTON AREA FOR 4-POT WILWOOD CALIPERS

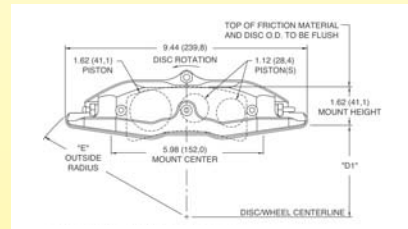
PISTON DIAM.		TOTAL PISTON AREA
Imperial (")	Metric (mm)	(Square mm)
1	25	1963
1 1/4	32	3217
1 1/2	35	3848
1 3/4	38	4537
2	44	6082

It can be seen that an ideal replacement for a 4-pot Princess caliper (TPA 4537sq mm) is a Midilite caliper with 1.5" pistons (TPA 4537sq mm). Similarly, to replace a Series 2 RS Turbo single pot slider (TPA 5655sq mm) use a Midilite caliper with 1.75" pistons (TPA 6082sq mm).

The effect of increasing/decreasing master cylinder size is often misunderstood. Increasing the master cylinder bore diameter will reduce power, decrease pedal movement and give a firmer pedal.

Decreasing the master cylinder bore diameter will increase power, but at the expense of a longer pedal. However, the opposite is the case with caliper piston size.

Increasing the caliper piston size will increase power but give a longer pedal. Decreasing the caliper piston size will reduce power but give a shorter pedal movement.



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combination has an 'E radius' of 147.5mm, x 2 add 5mm clearance = 300mm minimum wheel internal diameter.

By now you should have selected your caliper choice, selected your caliper piston diameter, decided between solid or vented rotors, decided between production disc or racing disc/ally bell and calculated your preferred disc diameter which will fit inside your wheels.

### OEM STRUT/UPRIGHT

To progress the design you will need to remove an upright/strut assembly from the vehicle or secure an identical unit from a breakers. The unit must have track rod ends, bottom knuckle joints and any component which will restrict the inboard movement of the disc, mount the assembly horizontally in a vice.



Sliding piston carrier type calipers have no pistons outboard of the disc to give a tight OEM accommodation package, but these vehicles are usually the more challenging to install pistons outboard of the disc between the disc working face and wheel spokes.

### DISC (ROTOR) SELECTION

If you view the Wilwood racing disc page elsewhere in this catalogue, you will see that the rotor choice is either racing disc with separate ally mount bell or production disc with integral cast bell.

The racing rotor is normally the preferred option above 300mm diameter where the weight saving of ally bell is balanced by the extra cost, complexity of hardware and runout considerations. Below 280mm diameter the extra cost is not normally cost effective. The production disc with integral bell is normally the preferred option for disc diameters 230 to 285mm.

Rally Design has had manufactured a limited range of production discs with no mount PCD holes in the bell face and minimum spindle bore diameter to allow DIY drilling/machining to suit many varied applications.

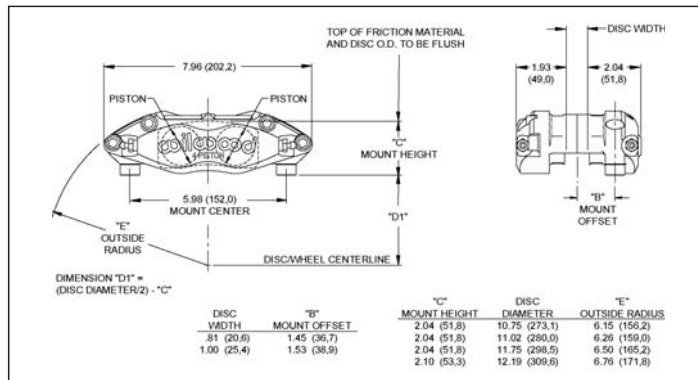
Note a racing disc/ally bell combination normally adds average £200.00 to a kit over the production disc option.

Thicker discs have more stability and cool better especially in curved vane design, but they are more difficult to accommodate within the design.

### THE DESIGN PROCESS

Your wheels are the limiting factor in disc/caliper choice and whilst all Wilwood calipers are designed with a very low profile, you cannot get a 'quart into a pint pot'!

If you are considering the purchase of a new set of road wheels you should always select both brakes kit and wheel choice in tandem.



The sectional drawings for all Wilwood calipers have a dimension 'E outside radius' which varies according to disc diameter.

For example, a 280mm disc diameter/Midilite caliper combination has an 'E radius' of 159mm, x 2 add 5mm clearance = 323mm, this is the minimum wheel internal diameter to accommodate this disc/caliper combination. Similarly, a 260mm disc diameter/Powerlite caliper



### BUYING YOUR COMPONENTS

I strongly recommend that you buy your selected brake components at this stage, including your choice of brake pads - within the Wilwood catalogue is a description, heat range and usage chart for all Wilwood pads - the new Wilwood 'Smart' pad is a particularly useful road/track day/light rally pad for general use.

Do not worry if you have made the wrong choice, we will always exchange components, but please ensure that you unpack and handle carefully. Components must be returned in new condition in un-soiled packaging for resale. Note if you scratch it, file it, cover it with grease or copper slip, you own it!

However, whilst I have seen professionals design a brake system on CAD CAM, for DIY design you do need the brake components to gain a 3D perspective. You will need your smallest ID road wheel to check clearance.

### SELECTION OF DISC TYPE

If you have selected racing disc/ally bell combination then the brake disc and bell face machining are free for you to choose.

However, if you have selected production disc then you have to accept the bell offset as stated and this may be unsuitable.

If the latter is unsuitable then you have no choice other than to explore motor factor disc catalogues to find an alternative disc diameter/spindle hole diameter/4-5 stud/bell internal diameter to meet your requirements - Rally Design will try to assist, but the choice is enormous and a solution not always available.





## POSITIONING THE BRAKE DISC



At this stage you cannot fit the rotor/bell assembly to the upright, but it is necessary to position the disc in its ideal location and slide caliper/pad assembly onto the rotor to check all clearances.

What is needed is a dummy bell. I have seen dummy bells made from MDF, sheet metal, even cardboard stiffened with GRP resin, as long as the dummy bell supports the rotor in its selected position. This inboard/outboard rotor position is normally determined by 5mm minimum clearance between the inside working face of the disc and track rod end or knuckle joint.

Offer up the road wheel to the above rotor/caliper combination to check caliper/road wheel clearance, ideally 5mm clearance should be available. Do not forget that as the brake system heats up it will expand so 2mm is not really enough!

You are now in a position to select your mounting bell. Note that all Rally Design bells are to suit rotors with (8) 5/16 UNF bolts on a 7.00 bolt circle diameter (BCD) and all bells are intentionally left with 5mm excess machining allowance on faces A, B and C (see bell sectional sketch).

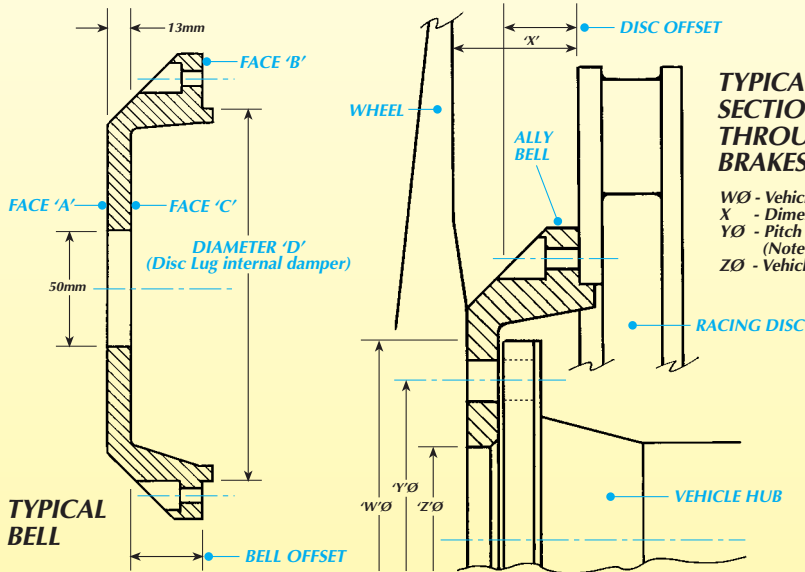
With (5) different offsets of bell it is possible by careful machining to position the disc from 0-50mm offset, covering most and track rod end or knuckle joint.

applications. The spindle bore at 50mm is less than most vehicle spindles (example: most Fords are 63.5mm spindle diameter), so is easily opened out to suit.

We suggest when buying your brake components you buy bells either side of your selected choice and return the unwanted bells for refund.

### BELL OFFSET CHART

PART No.	Bell offset (mm)
Univ 5	0 - 10
Univ 15	10 - 20
Univ 25	20 - 30
Univ 35	30 - 40
Univ 45	40 - 50



### TYPICAL SECTION THROUGH BRAKES KIT

WØ - Vehicle hub/diameter  
 X - Dimension, disc - wheel spider  
 YØ - Pitch circle diameter, vehicle studs  
 (Note if 4 or 5 studs)  
 ZØ - Vehicle spindle diameter (Disc bore)



### Notes on machining the bell

- Do not forget that you are looking for maximum 5 thou runout at disc rim so bell faces must be machined parallel  $\pm 2$  thou - make sure your machinist uses a lathe with minimal runout.

- Note the lug ID on different Wilwood rotors varies even if the 7" BCD remains the same, so ensure you take the disc along to the machinist to check lug ID. Allow 20 thou clearance lug ID/bell register, as the bell and rotor expand differently a close fit could cause the bell to distort or disc premature cracking.

- If your drawing is not proficient, we suggest you take the OEM disc along with the bell so that the machinist can take mount holes diameter/PCD, retaining screw details and spindle bore/chamfer details from disc and transfer to bell.

- Do not reduce any bell thickness below 8mm.

### DESIGN MOUNT BRACKET

Our mount brackets for Powerlite, Midilite and Superlite 4/6 are basically a length of ally bar sufficiently long to accommodate the 5.08" mount centres (Powerlite) or 5.98" mount centres (Midilite and Superlite 4/6). We have tried to machine these bars to bolt to the caliper, but this normally causes more problems than it helps.

Assemble machined bell/rotor to strut/upright, assemble pads to caliper and position caliper so that edge of pad is 1mm inside disc rim.

Cut a plywood or MDF template with holes drilled to bolt this template onto strut lugs. Drop (2) M10 bolts through caliper radial mount holes and space out template until M10 bolts are on centreline template. By measuring half thickness of template and total required spacers you have dimensioned the centreline of the M10 holes in the bracket. Check, using a Vernier, the difference in height between top of template and underside of caliper at the mount point and this dimensions the caliper/bracket post height required.



Note on some kits the post height will be minimal, possibly just a washer, on some kits it can be plus 20mm - we tend to have a maximum post height of 18mm, any more can cause the caliper to flex. If you post height is greater than 18mm then increase the height of the top of the bracket.



# Rally Design

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# GENERAL POINTS

## BIGGEST IS BEST

We have seen quoted elsewhere that 'biggest is best' - this is rubbish; a degree of common sense is required. A 330mm rotor with Superlite caliper on a 100bhp Vauxhall Nova may have the 'wow' factor to some eyes but you will be running supersoft pads to get the brakes to sufficient working temperature and the unsprung weight penalty will do nothing for the handling.

## DUST SEALS

The subject of dust sealing is controversial. The Midilite and Superlite 4 calipers are fully dust sealed, but really we had no piston seizing problems with older non-dust sealed calipers. In a race environment the dust seals can be a real nuisance and easily subject to heat damage and deterioration.

## X-DRILLING, GROOVING

Our honest feelings are that x-drilling and grooving or combinations are fashion accessories and if you like them we are happy to provide.

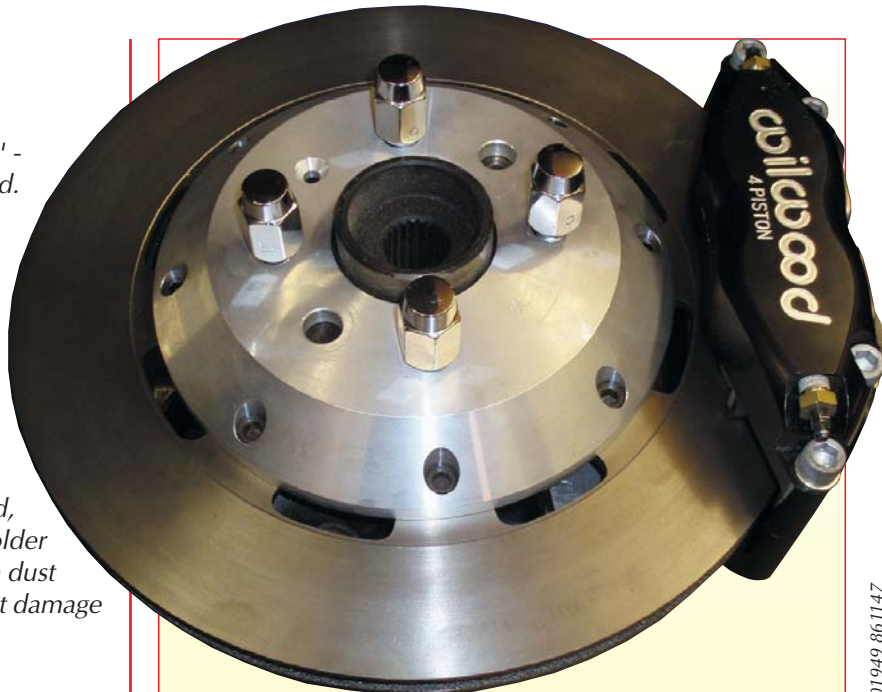
They do cause much higher wear rates of discs and/or pads and cause premature cracking of rotors, especially when subject to rapid heat transfer (rally water splashes!).

We are certain that you should not use x-drill discs with carbon metallic pads, this causes localised high friction coefficient hot spots and discs rapidly wear in a concentric furrow pattern.



**Rally Design**  
**IN HOUSE DESIGN**

We are happy to consider designing a kit FOC for a customer, provided we can see a future market beyond the one-off. If you would like us to design your kit please make direct contact with Rally Design.



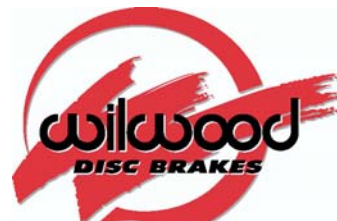
## THE FINISHED BRAKES KIT

*I must say that if you found the foregoing difficult to understand, despite written as simple to communicate as I can, then you should not contemplate designing your own brakes kit.*

**BRAKES ARE OBVIOUSLY A SAFETY CRITICAL ITEM AND YOUR LIFE AND THE LIVES OF OTHERS ARE DEPENDANT ON YOUR DESIGN**

David Elderfield - Senior Designer,  
Rally Design Limited

**RALLY DESIGN ARE THE EUROPEAN DISTRIBUTORS FOR WILWOOD BRAKES**



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