# *BMW E30 FRONT BRAKE UPGRADE*

By Geoffrey R. Turner

## 1. INTRODUCTION

In this article I describe how I upgraded the front brakes on my modified E30 BMW using Ferodo DS2500, 280 mm diameter, slotted discs and Alcon four-piston, H-type, radial mounted calipers. My *recipe* is compatible with 15" rims, but is by no means the only workable solution. There are, I am sure, many other brake calipers and discs that may be selected for this task, in which case this article may serve as a guide to those wishing to attempt a similar operation with similar components. If you have a limited budget to spend on your brake upgrade then, at the very least, consider fitting superior calipers, pads and hoses. Increasing the diameter of your discs, while retaining the same calipers and pads, will increase the braking wheel torque by a factor roughly equal to the ratio of the new to old disc diameters, but will not increase the force exerted by each caliper upon the disc (assuming that you are using a disc of similar material). Thus, unless you opt for substantially larger diameter discs, which will undoubtedly require larger diameter rims, you will achieve noticeably better results by fitting new calipers and pads. Be aware, however, that the heavier the disc, the greater its heat capacity (thermal mass). Thus, if you plan to use your brakes regularly and hard, I would suggest that you upgrade your brake discs in order to avoid problems with overheating.

Some manufacturing of items is required to follow this article. At the very least you will require a lathe and a milling machine to undertake these tasks. Unless you are competent to manufacture these items yourself, have them manufactured by a professional at your local engineering works. The attached drawings are sufficiently detailed that you should be able to hand them over to a professional and expect a well made product in return. Having said this, understand that there is no process presented here that cannot be reversed. Should you be dissatisfied with the result, or decide that you wish to keep the parts when you sell the car, the original calipers and discs can be refitted.

Finally, these are your brakes that you are working on, and thus *your* safety is in *your* hands. It is your responsibility to ensure that the components you fit to your car are strong enough for your chosen application. Be sure to follow the manufacturers instructions that accompany your new callipers and discs carefully. I will not repeat those instructions here. Neither will I provide instruction on how to plumb in and bleed your brake system, or how to *bed-in* the pads. This article focuses on the manufacture and fitment of the brake hardware. Some information is, however, presented with regard to the selection of compatible wheel rims. Keep in mind that it is the accuracy to which the prescribed parts are machined that will determine the success of your installation. If the calipers are mounted out of square, your brake-pads will wear unevenly and you will initially have poor braking (until the pads have worn down true to the surface of the disc). Worse still, if the brake discs aren't mounted square to the hub axis, you will likely experience brake judder. This will effectively *increase* your stopping distance due to reduced caliper force upon the disc, and interfere with your ability to control the vehicle. If you experience problems during or after bedding-in your new brake-pads, disassemble the job, locate, and then rectify the fault. Don't take chances with your brakes, they are crucial to your safety.

## 2. PARTS LIST

The following parts are prescribed:

- 1 × Alcon, Advantage series, four piston, H-type caliper (left-hand, trailing edge, radial mounted), part number CRH304/28-38/41LT,
- 1 × Alcon, Advantage series, four piston, H-type caliper (right-hand, trailing edge, radial mounted), part number CRH304/28-38/41RT,
- 1 × pair Ferodo DS2500 brake discs, part number RCP83004,
- 2 × caliper mounting brackets, manufactured in accordance with the attached drawing,
- 2 × inner wheel spacers, manufactured in accordance with the attached drawing, and
- 2 × outer wheel spacers, purchased according to the dimensions of your wheel-rims.

The Alcon calipers are available either directly from Alcon in the UK, or are stocked by most reputable motorsport shops. The left and right-hand Alcon four-piston calipers cannot be interchanged since they are not identical. This is at first not obvious, since, with the relocation of a few fitments from one end of the caliper to the other, it appears possible to interchange them. Upon close inspection you will however see that the upper and lower pistons used in this particular 4-piston caliper are of different diameter. In fact, if a mark is made on the brake disc, and the disc is rotated in a direction corresponding to the forwards motion of the vehicle, then the mark on the disc must first encounter the smaller (38.1 mm) diameter piston pair *before* it encounters the larger (41.3 mm) diameter piston pair. If this is unclear, then download the Alcon brake and clutch catalogue from Alcon at: http://www.alcon.co.uk/, which contains detailed drawings of each of their calipers. The catalogue is located in their motorsport section.

The prescribed Ferodo DS2500 discs are typically employed as part of a performance upgrade on a number of older Volkswagen (VW) Golf, Polo and Jetta cars. They are sold in some counties as *VW Spitze* discs. They have, so far as I am aware, identical dimensions to the brake discs employed on some versions of the VW Sirocco and of the VW Corrado, on which up-rated front brakes were standard. As with the calipers, the prescribed Ferodo left and right-hand brake discs cannot be interchanged due to the grooves in the discs. The discs must be mounted such that the grooves work to sweep the brake dust *outwards* as the vehicle moves in the *forwards* direction. If you are likely to forget this, then mark the face of the discs with a permanent marker as you remove them from their packaging. It is noted, with some irritation, that Ferodo identify the left and right-hand brake discs as the *passenger* and *driver* discs, not realising that some customers may be equally familiar with both left and right-hand drive vehicles.

## 3. DISC AND HUB MODIFICATIONS

The prescribed Ferodo discs must first be modified in order to fit the E30 hub. This entails enlarging the centre mounting hole to 66 mm, and enlarging the retaining-screw hole to 8.5 mm. The former operation is best performed of a lathe, while the latter operation can be performed with a bench drill since its accuracy is not critical. A drawing of a modified right-hand disc is shown in Figure 1.

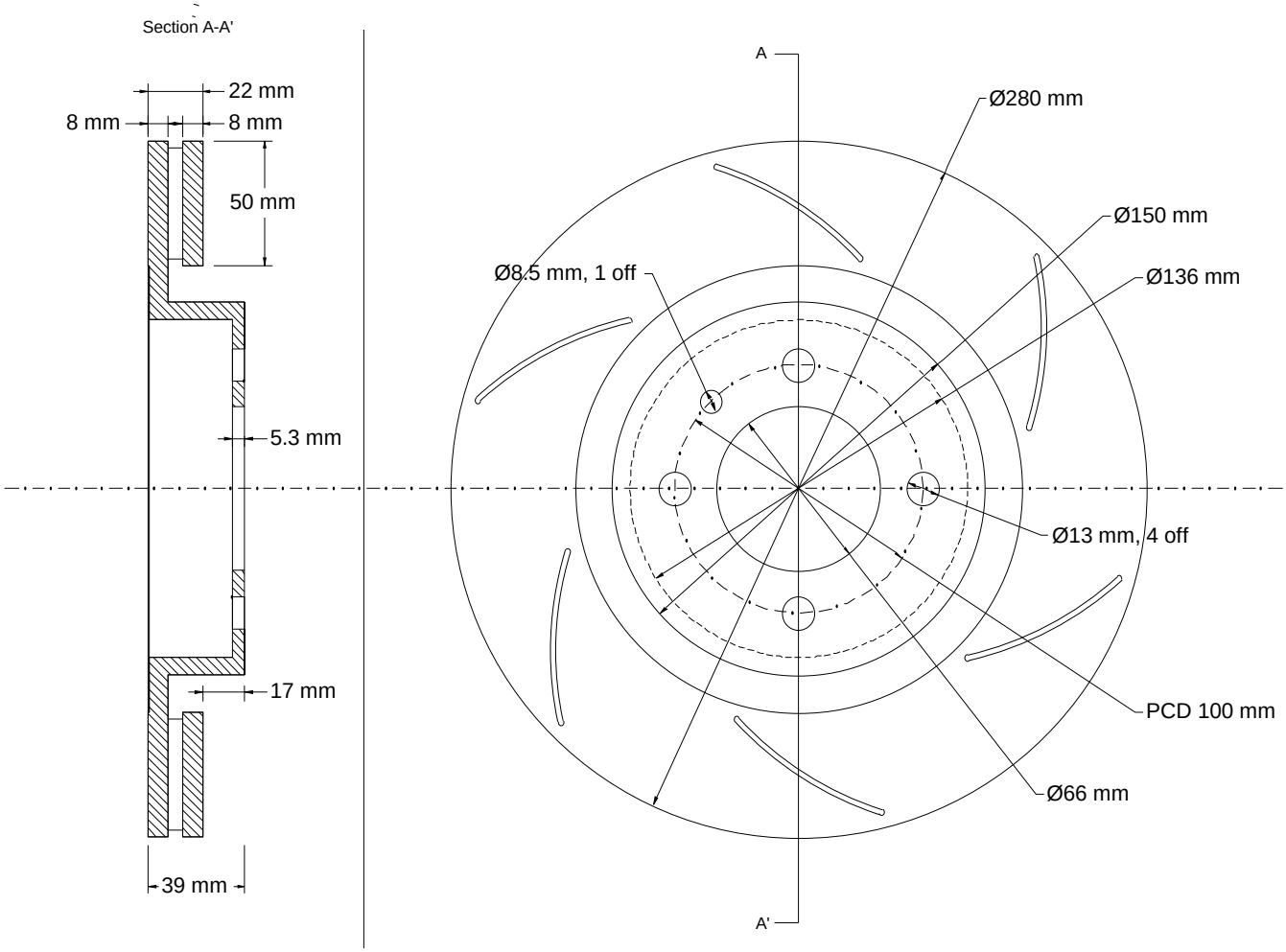


Figure 1: The modified Ferodo brake disc.

You will, at this point, notice two things of significance if you attempt to fit one of the modified discs to an E30 hub. Firstly, due to the curved lip on the edge of the mating-face of the E30 hub, the disc will not fully slide into position. Secondly, the retaining-screw hole in the VW disc does not align with that in the E30 hub. An inspection of Figure 1 shows that VW place the retaining-screw hole on the same pitch circle diameter (PCD) as the wheel bolts, while on the E30, BMW placed it somewhat inside of the wheel-bolt PCD.

The first problem can be dealt with by machining a 2 mm $\times$ 2 mm chamfer onto the *inside* edge of the disc centre hole. This will enable the disc to clear the curved lip on the edge of the E30 hub. I would, however, advise *against* this for the simple reason that, with the disc in place, you will find that the inside face of the disc working surface is in very close proximity to the track-rod-end. You will typically observe,

at best, a 1 mm to 2 mm clearance between the disc and the track-rod-end rubber boot. In fact, if the rubber boots are a little worn or perished, they may even touch the disc. To my mind, this is too close for comfort. I therefore specify fitting a 3mm spacer between the disc-centre and the hub in order to increase the separation between the disc and the track-rod-end. The chamfer, required to clear the curved lip on the edge of the hub, is thus machined onto the spacer, rather than onto the brake disc. This has the additional advantage that the centre hole of the disc need only be enlarged to 66 mm each time you fit a new set of Ferodo discs, with the chamfer permanently in place on the spacer. Details of the prescribed 3 mm wheel spacer are presented below.

The second problem can be solved by drilling and tapping a second retaining-screw hole into the E30 hub, 180° from the original hole. This solution may sound extreme, but given the number of components that you are going to attach to each E30 hub, two spacers and a brake disc, I find it easier to drill and tap a new retaining-screw hole into each hub, rather than to drill a new hole into each spacer and disc. Also, in my personal experience (yours may differ), wheel spacers and braking components that conform to the VW system are easier to obtain than those for the E30.

Since the purpose of the retaining-screw is simply to hold the various components in place when the wheel is removed, the accuracy in placement, as well as the strength of the thread inside the hole, is not critical. This is one job that I am thus prepared to tackle with a handheld electric drill in order not to have to remove the hub from the car. The easiest way to locate the position of the new hole is to fasten the new disc and 3 mm spacer to the hub with four wheel bolts, and then commence the drilling of the hole in the hub through the disc with an 8.5 mm drill (which corresponds to the size of the retaining-screw hole in the modified disc). Be careful to drill only deep enough to penetrate the surface, you do not want to open up an 8.5 mm hole in the hub. Now, remove the disc and spacer, and drill the now clearly defined hole to completion with a 6.7 mm drill, and then tap it with an $M8 \times 1.25$ mm tap. If in doubt, have someone watch you side-on to ensure that you drill square to the hub. You can use a spare wheel-bolt or similar to lock the hub in place, and thus prevent it from turning while drilling. Use cutting fluid such as Tapomatic or Tapol (for steel) to aid in both drilling and tapping. Remember, the steel of the hub is fairly hard, so drill and tap slowly and carefully - it’s not as if you can put the shavings back and start again if you get it wrong. Use a three-stage tap to tap the hole by hand. Be careful not to snap the taps off inside the hole as a broken tap is difficult to extract.

Tapping this additional locating hole on the hub face will in no way prevent you from replacing the original E30 brake components at a later date. However, if you would prefer not to drill an additional hole into your hub, I would recommend that you drill a second retaining-screw hole, that corresponds to the existing retaining-screw hole in the E30 hub, into the brake disc and any wheel spacers you may fit. Bare in mind that it will be necessary to drill this hole into any VW wheel components that you fit between the wheel and hub in future. I *do not* recommend fitting your brake disc to the hub *without* a retaining screw.

## 4. THE INNER WHEEL SPACER

A drawing of the prescribed inner wheel spacer is shown in Figure 2. A 2 mm $\times$ 2 mm chamfer is cut into the inside edge of the spacer centre hole in order that the spacer fit correctly onto the E30 hub. The spacer includes an 8.5 mm diameter hole for the retaining-screw. I manufactured my inner wheel spacers from 3 mm thick aluminium plate. It is doubtful that you will ever apply sufficient force to the wheel-bolts (which tighten down upon the disc) to deform the 3 mm thick spacer, provided you torque your wheel bolts correctly. Remember, it is the frictional force between the respective surfaces of the disc-centre, spacer and hub that bind them together. This frictional force is a function of the torque applied to the wheel nuts when the wheel is fitted. It is not, as many believe, the shaft of the wheel bolts that prevents these surfaces from moving relative to each other. Provided the wheel bolts have sufficiently high tensile strength to sustain the friction between the respective surfaces, and provided that none of the components deform, you have a safe and workable solution.

It is interesting to note that the shear strength of a bolt is substantially less than its tensile strength. Thus, if a rotational force (wheel torque) is applied to a wheel sufficient to exceed the frictional forces between the respective surfaces, the surfaces will rotate relative to each other, placing an extreme shear force upon the bolts, often shearing them off completely. This is why, either under extreme braking or acceleration (tyre traction permitting) it is possible to shear off your wheel bolts. This is especially true if you forget to tighten your wheel bolts, since the wheel torque required to break the frictional bond holding the respective surfaces together is now less. I therefore recommend that you do not forget to torque your wheel-bolts.

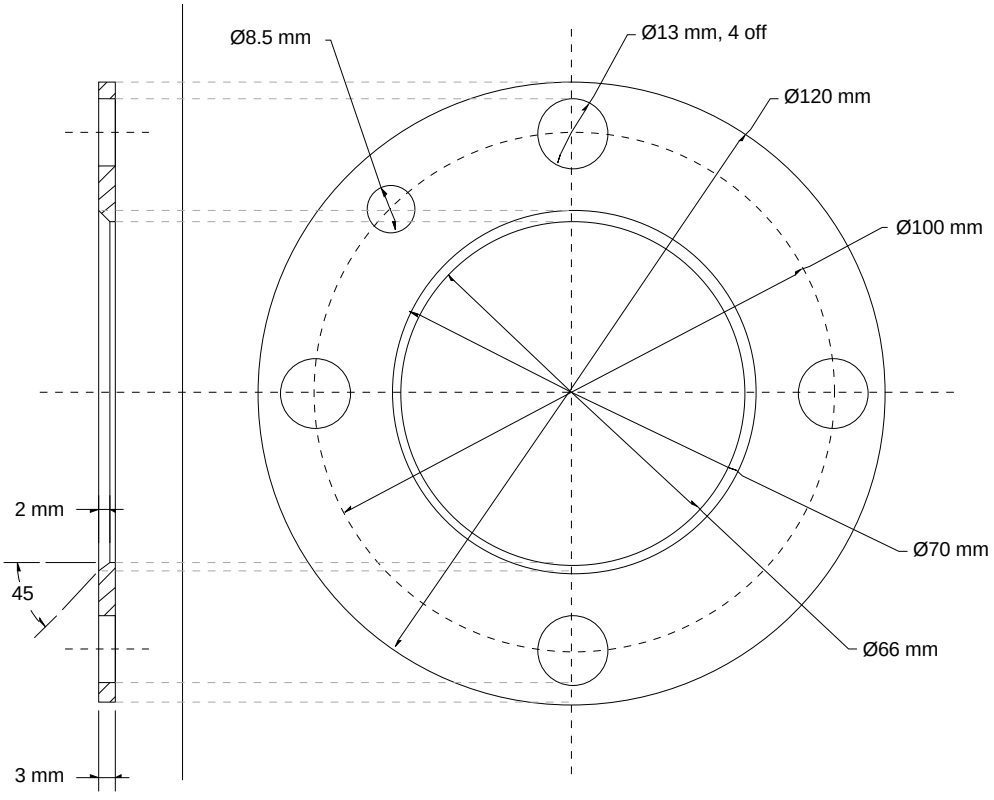


Figure 2: The inner wheel spacer.

A top view of the assembled inner wheel spacer, the right-hand disc and right-hand E30 hub are shown in Figure 3. Unnecessary details of the hub have been omitted for clarity. Note that, despite the use of a spacer between the hub and disc, the lip of the hub is sufficiently exposed to accurately locate the disc on the hub. It would, however, be inadvisable to use a spacer any thicker than 3 mm. Remember, if the disc is not located concentric to the hub axis (termed *hubcentric*) your wheel will be out of balance, since the mass of the disc will be non-uniformly distributed about the axis of the wheel, and you will feel this as a vibration. This vibration places undue stress upon the wheel bearing that will eventually result in bearing failure. Thus, ensure that you fit the disc concentric to the hub axis. It goes without saying, therefore, that the 66 mm diameter hole must be machined *precisely* in the centre of the disc.

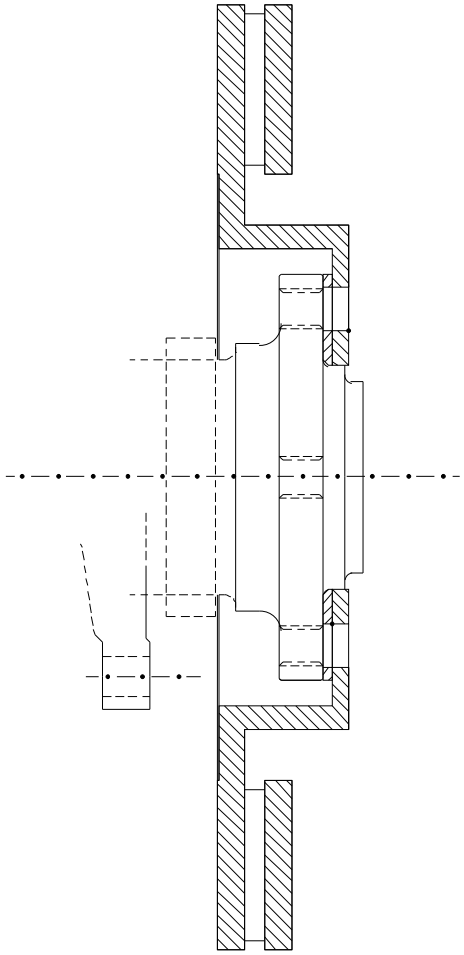

Figure 3: Showing the brake disc and inner wheel spacer assembled on an E30 hub.

## 5. THE CALIPER BRACKET

Two brackets must be manufactured in order to attach the Alcon calipers to the standard E30 caliper mounting points at the rear of the E30 hub. A drawing of the brackets is shown in Figure 4. Each bracket is milled from a 180 mm long piece of 50 mm $\times$ 50 mm 6082 aluminium square bar. 6082 Aluminium is sufficiently strong for this application given the overall small size of the bracket and the large wall thickness.

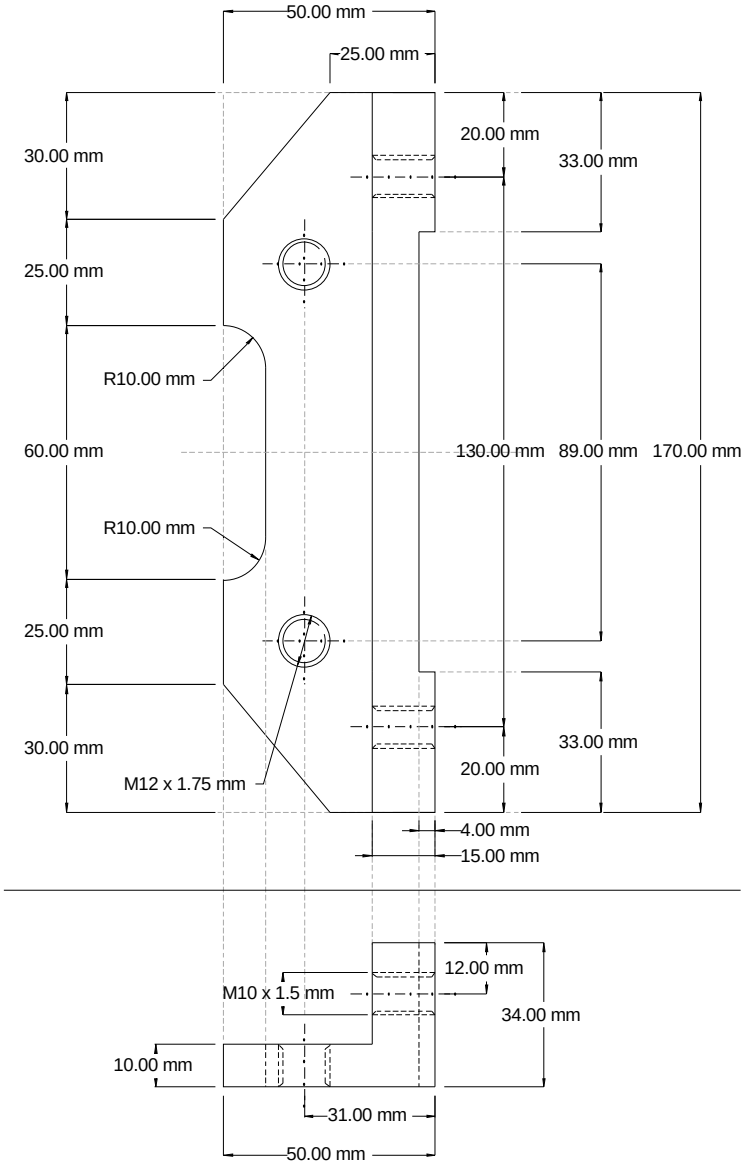


Figure 4: The caliper mounting bracket.

Each bracket includes a 10 mm deep recess along its left-hand edge in order to avoid pressing against the rear of the rotating hub, and a 4mm deep recess along its right-hand edge in order to mate correctly with the caliper. Each bracket bolts to the original E30 caliper mounts with two M12 $\times$ 1.75 mm pitch $\times$ 30 mm long, high tensile steel hex or Allen-head bolts. Each caliper bolts to its respective bracket with two M10 $\times$ 1.5 mm pitch $\times$ 60 mm long high tensile steel Allen-head bolts. Due to the restricted space around the caliper, only Allen-head bolts may be used to attach the caliper to the bracket.

To ensure that the calipers align correctly with the hubs and discs, it is essential that the four mounting holes be drilled accurately, preferably milled. Remember, these four piston calipers are of the type defined as *fixed calipers* and, unlike the common single piston *floating caliper* found on most budget cars, they do not self align. Thus, it is essential to manufacture these brackets accurately. Of particular importance is the squareness of the bracket, and the location of the mounting holes.

## 6. FINAL ASSEMBLY

A top view of one example of an assembled right-hand front wheel is shown in Figure 5. The Alcon caliper is shown bolted to the caliper bracket, which is, in turn, bolted to the standard E30 caliper bolt holes. Note how the centre line of the caliper is aligned with the centre of the disc working surfaces. This must be kept in mind should you decide to design your own brake upgrade using your own components, in order that the caliper pistons (on both sides of the disc) displace equally while braking.

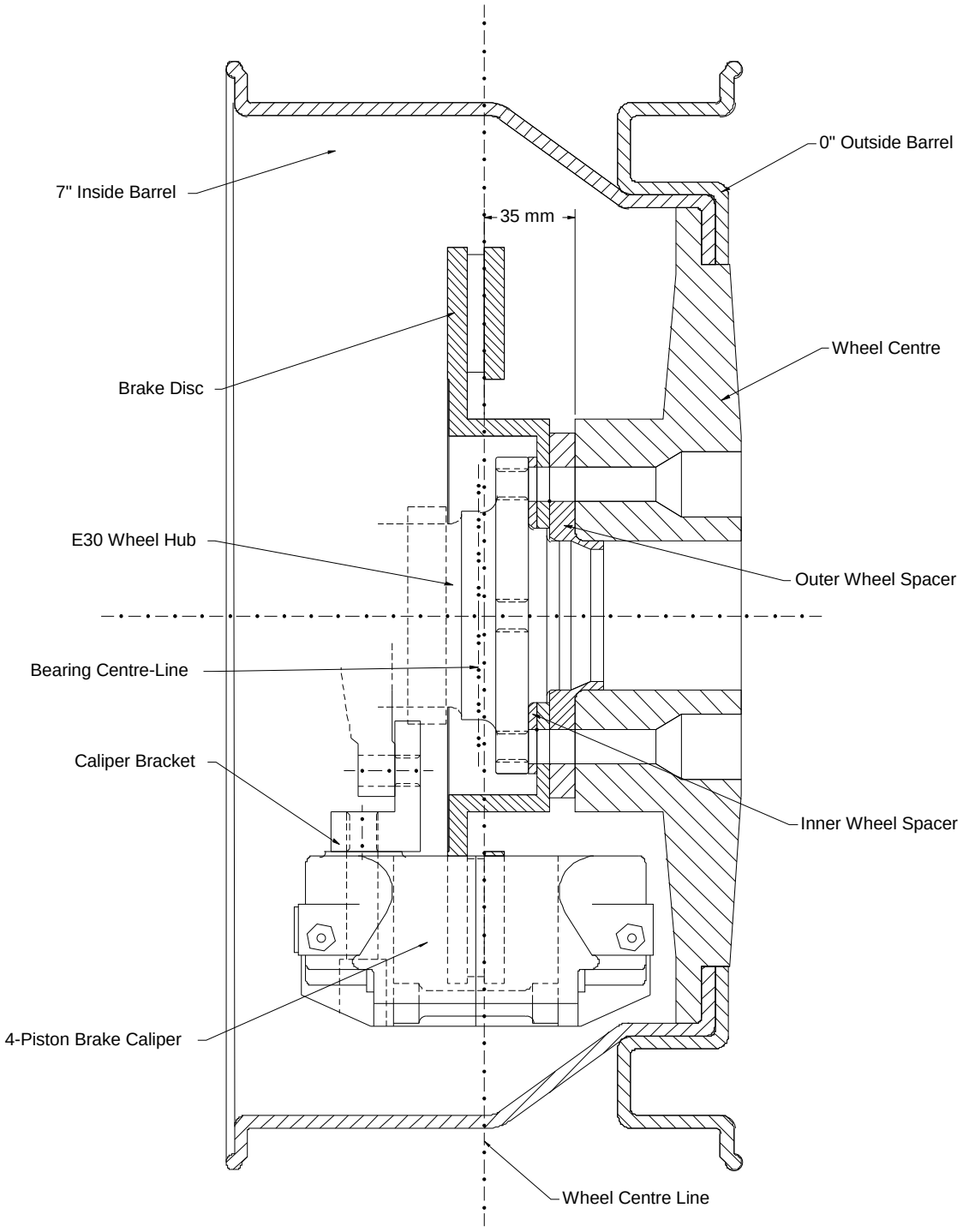


Figure 5: Showing the top-view of an assembled right-hand wheel.

The example shown in Figure 5 uses a 15” × 7J, 3-piece, Gotti split rim and a 10 mm wide hubcentric wheel spacer between the wheel-centre and the disc-centre. The rim comprises a 7” inner and a 0” outer barrel. The Gotti wheel offset, as configured, is 35 mm, which effectively reduces to 22 mm with the inclusion of the spacers. The preferred offset of 24 mm may be achieved by machining the outer spacer from 10 mm down to 8 mm. This will however place the inside of the 15” Gotti wheel-centre precariously close to the caliper. Thus, with the rim and spacers in place, the wheel centre-line is 2 mm outside of the wheel bearing centre-line. This is within tolerances.

This is of course only one example of a rim that can be fitted around the presented brake modification. Regardless of which rim is fitted, however, the wheel centre-line should be within a few millimetres of the bearing centre-line in order to maximise the life of the wheel bearings. Attempting to fit rims with an already small offset (< 24 mm) or excessively wide rims (that would typically collide with the strut if the wheel centre-line were over the bearing centre-line), or unnecessarily fitting wheel spacers for the purposes of aesthetics, will result in the wheel centre-line passing *outside* of the bearing centre-line. Provided the wheel offset is already greater than that required on the vehicle, and provided the wheel does not collide with the brake caliper, strut or wheel arch, a wheel spacer may be machined to size whose dimension will achieve the ideal offset of 24 mm. If the wheel offset is already less than 24 mm, there is nothing that can be done, short of modifying the rim, to increase the wheel offset. The thickness of the wheel spacer required for your application could also be affected by the profile and thickness of your wheel centres, so measure up carefully before you start machining or buying wheel spacers.

A further disadvantage of reducing the wheel offset below the optimum value is increased *scrub radius*. Increasing the scrub radius will facilitate smooth and easy steering while trying to park, but will result in increased steering force while braking (termed *brake-steering*) which will tend to make the vehicle understeer (straighten out) while *simultaneously* braking and turning. This is clearly non-ideal, and will also result in excessive wear on your track-rod-ends and other steering related components. Thus, the incorrect choice of rims will result in overall increased wear-and-tear on your cars front-end wheel related components. Also, be sure to fit the correct length wheel bolts that go *all the way through* the bolt-holes in the hub!

Finally, it is interesting to note the effect of the 17 mm offset of the Ferodo brake discs (see Figure 1), compared to the 13mm offset of the standard E30 discs. With reference to Figure 5, the further inboard the disc is moved, the further inboard the caliper can be moved, and thus the thinner the wheel spacer required to prevent the caliper from colliding with the inside surface of the wheel centre. It is unfortunate, in the case of the E30, that the track-rod-end is so close to the disc, otherwise the larger offset of the Ferodo brake disc could be put to 3 mm better use. It should however be noted that BMW specified a brake disc with a 13 mm offset not only to avoid the track-rod-ends, but also to align the centre line of the brake disc with the centre-line of the wheel bearing. The 3 mm inner spacer thus places the centre-line of the VW disc within 1 mm of the wheel bearing centre-line.

## 7. RESULTS

Figure 6 shows an Alcon calliper, Ferodo disc and a 10 mm Isotta wheel spacer attached to the front right-hand E30 hub of my track car. All parts are as described above. This particular car has a tubular space-frame and a modified suspension, and thus does not resemble an E30 BMW in any other respect. Note the M8 $\times$ 1.25 mm counter sunk Allen-head screw used to secure the disc and spacers to the hub. This screws into the newly tapped retaining-screw hole.


Figure 6: Showing the assembled Alcon caliper, Ferodo disc and Isotta wheel spacer attached to the E30 hub.

Figure 7 shows the aluminium mounting bracket which attaches the Alcon caliper to the standard E30 caliper mounting points. A Gotti rim with tyre are fitted to provide some indication of the size of the brake components compared to the wheel. In all respects, other than those exceptions presented above, this is a standard E30 hub extracted from a 325i E30 BMW.

Keep in mind that to correctly operate these Alcon four-piston calipers, as well as provide balance between your front and rear brakes, you may need to reassess the operation of the brake master cylinder on your car, something that I have not discussed in this article. You will also need to select the correct compound FRP219 Ferodo brake-pads to suit your application.

Figure 7: Showing the mounting bracket which attaches the Alcon caliper to the standard E30 caliper mounting points.

I trust that the information I have presented in this article will assist you in upgrading the front brakes on your own E30, and choose rims to fit, whether for race purposes, or simply to provide greater stopping power to match the increased power of a transplanted 24V engine.