Brake Systems for BMW Motorcycles

by Ron Schmidt

Brake Systems As Applied To 1970 BMW & Newer BMW Motorcycles

Preface: The light turns yellow and you decide to stop, rather than run through the red as is the norm for Utah drivers. You apply the brakes; your BMW comes to a controlled stop. Brakes are just another part of our BMW that we expect to work flawlessly. But what is really happening when we apply the brakes?

In the simplest of terms, the brake system changes the moving (kinetic) energy of the bike and riders to heat energy. The heat is generated by friction between parts that rub together, and that heat is dissipated by the cooling air passing by it. The more heat a brake can generate and dissipate, the stronger the braking force is available. Once the brake is unable to dissipate the heat it has generated it will "fade" and become less effective.

The brakes on our motorcycles are capable of generating forces far greater than the engine develops. This can easily be understood if you think about how long it takes to accelerate your motorcycle to any speed and how much less time it takes to stop it from that same speed. So, next time some smart kid on a rice rocket says your BMW is slow, tell him that it makes over 200 HP. You don't have to tell him that it is the brakes you are talking about!

Brake Basics: On a BMW motorcycles there are only two main types of brakes:

◊ Internally Expanding Drums

◊ Disc/Caliper

There are varying styles and operating mechanisms for each.

Internally Expanding Drum Brakes

Internally expanding drum brakes were used on the front and rear of all /5 models and /6 models 600cc and smaller. In later years, some of the airheads and K75 models still had drum brakes on the rear. All drum front brakes were double leading shoe (DLS); the rears were single leading shoe (SLS) types. All were mechanically operated by cable or rod. The necessary force needed to make these brakes powerful enough to be effective was supplied by the rider's hand or foot applying force to a series of levers that multiplied that force. These levers include the hand lever or foot lever, the lever arms on the cam that operates the brake shoes, and the size of the cam itself.

Single Leading Shoe — A SLS brake is the simplest of all BMW brakes. The two brake shoes are spread apart by a cam pushing on one end of each shoe, and pivot on a pin on the other ends of the shoes. The brake shoes are pushed out onto the inside of a brake drum. The rubbing of the shoes on the drum generate the heat.

Double Leading Shoe — A DLS brake is just slightly more sophisticated but much more effective than a SLS brake. The part of the brake shoe that is closest to the operating cam in the direction that the drum turns is called the "leading edge" of the shoe. When the leading edge comes in contact with the drum, it has an amount of self energizing affect as the shoe tries to "jam" itself against the spinning drum. The other end of the shoe is the "trailing edge" and just has some minimal pressure on it. On a DLS brake, there are two cams; the second cam takes the place of the pivot pin of a SLS brake. So the DLS brake has two "leading edges" that have the self energizing affect, therefore increasing the brake force substantially. Just as an interesting note, the DLS brake is very poor if you are rolling backwards as there are no "leading edges" at all in this situation!

A properly adjusted BMW DLS brake has very good power, near what a single disc would have, at least until the brake overheats and begins to fade.

Disadvantages of Drum Brakes — The disadvantages of drum brakes compared to disc are:

● Unsprung Weight

● Inability to dissipate heat efficiently

● Vague “feel” caused by stretching internal cables, compressing external cable housings, and flex in

the levers

Disc/Caliper Brakes

BMW motorcycle disc brakes are hydraulically operated, although 1974 to 1980 models over 650cc had a cable from the hand brake lever to the mastercylinder which was mounted under the fuel tank.

There are a number of basic components in a disk brake system.

(1) Master cylinder

(2) Brake fluid

(3) Brake lines & hoses

(4) Calipers & caliper pistons

(5) Brake pads

(6) Brake disks

The force provided by the hand or foot of the rider pushes on a lever, moves a piston in the master cylinder that supplies pressure on the non-compressible brake fluid contained in the brake lines and hoses. The pressurized fluid supplies force to the caliper pistons (except in the case of the IABS, see below) which push the brake pads against the brake discs. The pads rubbing on the discs cause friction and therefore heat.

(1) Master Cylinder

The master cylinder assembly is usually located on the right side of the handle bar. It holds brake fluid and has a piston inside that moves, exerting pressure on the brake fluid when the brake handle is activated.

(2) Brake fluid & DOT ratings

Brake fluid supplies the non-compressible medium between brake parts. The brake fluid is also the lubricant and the anti-corrosive needed in the brake system.

As in any brake system, the important issues concerning the use of particular type of brake fluid include: (1) fluid compatibility with the brake system rubber, plastic and metal components; (2) water absorption and corrosion resistance; and, (3) fluid boiling point and other physical characteristics.

Brake Fluid Grades – Brake fluid is rated by the U.S. Department of Transportation. The DOT ratings, in general, are based on the boiling points of the fluid, the chemical base of the fluid, and the additives. These ratings are set by the Society of Automotive Engineers.

The brake systems for all BMW motorcycles are recommended to use **only** *DOT 4 brake fluid (see Society of Automotive Engineers publication J1703); no other fluid grade is acceptable to retain your warranty or to assure optimum brake operation.*

Boiling Points – Boiling points are rated at dry and wet, with the wet at 3.7% water content in the brake fluid. The minimum dry boiling point of DOT 4 fluid is 446°F, and minimum wet is 311°F. Most DOT 4 fluids sold today have wet boiling points around 410°F and dry boiling points around 480-520°F, exceeding government minimums.

Hydroscopic Issues – DOT 4 is hydroscopic, meaning it will absorb water from the moist air around it. Because the fluid absorbs water, it needs to be flushed annually to keep the water content down. DOT 4's minimum dry boiling point is 446°F. Water boils at 212°F at sea level at 1 atmosphere of pressure (atm), and the boiling point temperature gets lower as you rise in altitude. The boiling point temperature rises as more pressure is applied. If the water percentage in the brake fluid is high, the fluid can boil at lower temperatures.

If your BMW's brake fluid reaches the boiling temperature, the water in it turns to steam, becomes compressible, and the end result is no brake pressure and loss of brakes. Also, the water will cause galvanic corrosion between the dissimilar metals in the brake system, which can cause very expensive part failures such as leaks in the mastercylinder/calipers or ruined ABS components. The inhibitors deplete over time which is another reason to change brake fluid annually.

Serious Considerations – As stated before, boiling temperature increases as pressure is applied. If the brake fluid in your BMW motorcycle has enough water in it to boil at normal air pressure (1atm at sea level, less here in Salt Lake City!), and if you use your brakes aggressively, you may generate enough heat to exceed the wet boiling point. The brake system pressure may make the boiling point high enough to stop the boiling. But, when you release the brake lever, the pressure goes back down to about 1 atm. At that pressure the brake fluid could begin to boil. Then the next time you try to apply the brake, the boiling fluid will cause you not to have any brakes! This could really be a problem, particularly if you are coming down a mountain pass at high speeds with a full load and a passenger and need to slow down for that next turn!! We cannot emphasize too strongly the importance of flushing your brake fluid annually.

Brake Fluid & Paint – DOT 4 brake fluids are very hard on paint, due to the polyethylene glycol, dissolving the paint right before your eyes if you get any on painted surfaces. A leaking master cylinder could cost a paint job as well as an expensive brake repair!

(3) Brake Lines & Hoses

Most BMW motorcycles come with rubber brake hoses, though many of the newer models now come with braided stainless steel hoses.

Rubber Hose – The construction of a brake hose is easy to understand if you look at it in a cross section. The cross section of a rubber hose, starting from inside and moving out, is: (1) a flexible rubber tube that is brake fluid resistant; (2) a wrapper of fiber mesh to control the expansion of the inner hose when under pressure; and, (3) an outer rubber hose that is weather resistant and protects the mesh.

The primary advantages of a rubber hose are: (a) low cost (it is inexpensive to manufacture); (b) it bends where you want it to go; and, (c) it works just fine for most applications. Disadvantages are: (a) the inner rubber hose will eventually degrade and foul the brake fluid; (b) it is not as resistant to the moisture in the air causing the brake fluid to need to be changed more often; and, (c) it looks like an old rubber hose!

Stainless Steel Braided Hose – The stainless steel braided hose has an interesting cross section starting from the inside and moving out: (1) a Teflon or similar plastic tube that is impervious to brake fluid; (2) a flexible stainless steel braid to control expansion under pressure; and, (3) sometimes there is a plastic sheath over the outer stainless steel braid to keep the braid from damaging any parts it might rub against. Also, the high end stainless hoses can be made with the connecting fittings of polished stainless steel which are beautiful! The advantages to stainless braided hose are: (a) inside hose does not deteriorate, makes brake fluid stay cleaner longer; (b) it does not expand when pressure is applied so brakes feel better (except on ABS models where the ABS modules make the change unnoticeable); (c) it will last almost forever; and, (d) it looks cool. The only disadvantages are that stainless steel lines are expensive and are not quite as flexible as the rubber hoses.

(4) Brake Calipers & Caliper Pistons

The brake calipers used by BMW are from a number of very high end manufacturers including ATE, Brembo, and Tokico. Calipers hold the piston(s) that press against the brake pad(s). The force that moves the pistons is the pressure exerted by the brake fluid.

The Caliper — A brake caliper needs to be rigid enough not to flex under the great force placed on it as the pistons are forced against the pads and then the discs. If the caliper flexes it reduces the force placed on the brake pad(s) which reduces the braking effect. Flex will also cause the brake hand or foot lever to feel vague to the operator. Conversely, the calipers must be light enough not to have serious detriment to the unsprung weight of the suspension/wheel/brake assembly. The weight is further important because the caliper is mounted to the steering, and excessive weight there has negative affect to the feel of the motorcycle. So, the calipers are made of light weight materials and designed with shapes that reduce the flex.

Caliper Pistons — The pistons inside the brake caliper(s) push the brake pads against the brake disc. The caliper pistons in the ATE calipers were steel and very heavy. The newer pistons are made of lighter materials. The light material is increasingly important as the ABS systems apply and release the brake force rapidly. The heavier pistons would be more resistant to these rapid pressure changes. The new light weight materials also have the advantage of transferring less heat into the brake fluid because the materials they are made of are less conductive. This is important, because the caliper is a very poor heat dissipater and overheated brake fluid can be a very real safety concern as we discussed in the brake fluid part of this seminar. As BMW motorcycles get heavier and faster these issues become more important.

(5) Brake Pads

Pad Types — Brake pads are available in different friction levels and materials. The most common pads now used are sintered HH rated.

Ratings – Currently the lowest coefficient of friction (cf) pad rating is FF, then GG, then HH. It is ok to upgrade to a better cf pad but you should never go backwards. FF, GG, and HH pads are all good for street applications as they warm rapidly. Full racing pads warm slowly so cold panic stops are not good. Do not use racing pads in street bikes.

High quality pads in are available from Ferodo, EBC, Dunlopad, and BMW. BMW pads are very high quality but are very expensive. Some brake squeaking with BMW pads can be improved by installation of EBC pads, particularly on the K1200LT.

(6) Brake Discs

All BMW motorcycles with disk brakes use stainless steel discs. They are a very good compromise between braking power, corrosion, and cost.

Solid Mount Discs – These were used on airheads and 2v K bikes. The solid mount design is simple and less expensive to produce. However, because there was no allowance for float, the machining of the discs and the surface on the wheels to which they mount had to be nearly perfect or the brakes would pulse. On 1974 to 1980 models the calipers could float enough to allow for some machining tolerance, but starting in 1981 forward on airheads and 2v K bikes, the calipers were solidly mounted and brake pulsing became an issue. If there was as little as 0.003" out of true at the outside edge of the disc, the brake would pulse badly. So the wheel mounting surfaces had to be within about 0.001". This close a tolerance was hard to hold. The solid mount discs were more likely to warp over time, more likely to squeal, and could not dissipate the heat as well as the more modern floating discs.

Floating Discs – These are used on all current BMW's. Advantages include better heat dissipation, reduced need for perfect machining, and the disks are less likely to warp or squeal. Their disadvantages include higher replacement costs, and wear of the buttons that the discs float on. Often R850/R1100 and K1100 models need to have the buttons

replaced by 40k miles. If buttons are allowed to wear too far the entire disc assembly will need to be replaced because the disc and the disc carrier will wear also.

Anti-locking Brake Systems (ABS)

Some BMW motorcycle models are equipped with ABS (antilock brake systems). The ABS systems monitor wheel speeds. When one wheel decelerates more rapidly than the other, the computer will cause pressure to that wheel to be pulsed to reduce the skidding. ABS on BMW motorcycles comes in four major types:

- ABS-1
- ABS-2
- IABS
- ABSN

ABS-1 — The ABS-1 was first used on the 1988 K100RS Special and was the first production motorcycle to use an ABS system. The ABS-1 was heavy and slow compared to the later generations, but really set the braking safety standard for motorcycles, a tradition that BMW continues to this day.

ABS-2 – The ABS-2 was lighter in weight and faster operating than the ABS-1, and in general was a real improvement over ABS-1.

IABS — In the case of IABS (Integrated Anti-lock Brake System) there are separate systems for the wheel circuits and the control circuits. The brake fluids in these separate systems never actually come in contact with each other. In the IABS system, the force the rider supplies to the levers is used to tell the IABS computer how much brake force the rider wants, and then the power assist servos actually supply the brake force through a separate hydraulic system to the calipers. The IABS computer will decide how to bias the front and rear brakes for you.

To complicate matters, there are 2 types of the IABS systems:

- Partially integrated
- Fully integrated

Partially Integrated — The partially integrated system is used on the more sporting models, i.e. R1100S, R1150R, R1150GS, R1200GS, R1200RT, R1200ST, R1200S, K1200RS, K1200GT, K1200R and K1200S and it integrates the brakes only when the hand lever is used. The footbrake lever only applies brake to the rear brake.

Fully Integrated — The fully integrated system is fitted to the BMW touring models, i.e. R1150RT, K1200LT, R1200CLC, and integrates the brakes whether you use the hand lever or the foot lever. On these models, it really does not make any difference if you use the hand or foot lever, as the computer is going to decide which brake calipers are used and how to bias the front / rear brake pressure.

In the case of a servo failure, there is a "residual" override that allows the rider to still have some braking power, but it is substantially compromised. The IABS, when operating properly, does result in less brake lever pressure than a normal system for the same braking force.

While the IABS is lighter in weight and faster operating than ABS-1 or ABS-2, it does lack the "feel" of normal brakes, adds much to the cost of maintenance, and does not allow an experienced rider to modulate the brake bias to his liking. However, it is the best thing in the world when a deer jumps out in front of you on a sandy back road, but has met with much resistance by many riders. Gotta love those German engineers!

ABSN– This system is used only on the various models of F650s. It is the lightest weight of all the systems and has a very rapid operation. Unlike the other ABS systems BMW uses, this system does have lever feedback (meaning you can feel the pulsing in the hand and foot levers as the ABS functions). ABS-1, ABS-2, and IABS does not have lever feedback.