Technical Committee

This month we'll discuss one of the most technologically advanced Corvette systems. No, not the cup holder; the F55 Magnetic Selective Ride Control suspension. First, just a short bit of history.

The basic suspension components, the spring and shock absorber, have been around since the first 1953 Corvette rolled off the assembly line. For our purposes, we will not discuss exact suspension types (i.e. double wishbone, MacPherson Strut, etc.) or the other ancillary components, like anti-sway bars. Since no roadway is perfectly flat, cars need suspensions to prevent your teeth from being rattled out every time you drive over a bump or into a pothole. Springs absorb the bumps so the large wheel moves do not transfer to the body and occupants. Unfortunately, springs would bound almost forever, and at their particular harmonic frequency, as they attempt to release all the energy absorbed after the wheel strikes a bump. So, shock absorbers, which are basically a two-sided oil pump, are added to dampen the wheel movement. First, to make the wheel come to rest faster than its intrinsic harmonic frequency and second, to prevent a very rapid wheel movement to transfer to body motion in the case of a very sharp road undulation.

From the very beginning, automobile engineers knew that the basic spring/shock absorber was totally reactive. The wheel strikes a bump and the system attempts to both keep the wheel in contact with the ground and not let the rapid vertical change transmit fully to the vehicle body. A Lincoln gives a very smooth ride to the occupants for minor road undulations, but the body and wheels move noticeably when driven over a large change in the roadway. Sports cars give a much rougher ride, as they are not as concerned with occupant comfort as with making sure the wheels stay in contact with the ground and the body stays relatively flat to the road. No one system could do both well. That's because conventional suspensions had: 1. No way to adjust real-time wheel response to changing road conditions and 2. Were independent of vehicle speed. Engineers went to the shock absorber to see if they could make the system react to the road. To do this you needed two things, a consumer who is willing to pay big bucks (i.e. expensive cars), and something fast enough to make the adjustments, (i.e. a computer.) Corvette's first attempt at this was SRC "Selective Ride Control", RPO FX3. It was standard on the ZR-1 and optional on other 'Vettes from 1990 to 1995.

SRC had plenty of different levels of ride stiffness or how much the shock dampened the ride. This wide range of adjustments is known as "bandwidth." Also, the SRC system could adjust for vehicle speed. Finally, the driver was given an input as well. He/she could select Touring, Sport or Performance. Unfortunately, computers and adjustable shock valves in those days were slow. The early SRCs had a 1/5 second response time, or about 180 milliseconds (ms). 1992 and later models cut that response time roughly in half. But, even these numbers they were way too slow. SRC was better than nothing, but needed improvement.

In 1996, RPO F45, Selective Real-time Damping (RTD) was introduced. It was a much faster reacting system (about 35 ms), but could not apply the full range of very soft to very stiff damping to totally react to the road. Continuously-variable RTD, with improved response times and accuracy of valve adjustments, was a refinement in the '97 C5. These systems were approaching the capability to literally read road conditions in almost real-time. Quite a feat for its day, but all of these systems used electrical actuators to move mechanical valves. The valve orifice change would adjust the oil transfer in the shock and thus, stiffen or soften the ride. No matter how rapidly the computer can signal a change, however, restrictions to fluid motion using mechanical valves are intrinsically slow and therefore, restrict the bandwidth of damping available.

Then, in 2002, GM Delphi introduced MagneRIde in the Cadillac and a year later F55 Magnetic Selective Ride Control in the Corvette. The primary engineering breakthrough was the use of Magnetorheological (MR) fluid and a magnetic field, rather than oil and mechanical valves, to provide the variable damping in the shocks. MR fluid consists of approximately 30% carbonyl iron particles (CIP) suspended in a synthetic hydrocarbon liquid. Amazingly, these Carbonyl iron particles have a variety of other uses in life. For instance, they are used to manufacture Corvette connecting rods and as iron fortifiers in food supplements.

Magnetorheological fluid (MF) has been around since the 1930s. Its defining property is its ability to drastically change the fluid's yield sheer in the presence of a magnetic field. Simply put, when a magnetic field is applied, it goes from being a fluid to being a semi-fluid/plastic. Until recently, the trick was to make this process work in an actual automotive application. Its manufacturer, the Lord Corporation, has cleverly overcome several problems inherent in suspending iron like particles in a fluid. First, the CIPs must be coated so they do not break down over time causing the shock to be filled with metallic shavings or flakes. Also, these microscopic particles must be coated so they do not grind away themselves and the shock walls. Finally, the CIPs are iron based and heavier than the liquid in which they are suspended. As such, they "settle to the bottom" much like any non-dissolvable powder in a liquid. Remarkably, the CIPs are returned to a fully suspended state in a little as a few shock absorber cycles even after being at rest for months. The Lord Corp. has been extremely close-mouthed about their proprietary process to make this fluid.

So, we have all heard how the fluid in the Magnetic Select Ride "changes the viscosity" of the shock fluid when the magnetic field is applied, thus leading to a stiffened shock motion. Well, that description isn't really accurate. The fluid remains in the same relative viscosity in the shock even with the magnetic field applied. However there are four channels (passages) cut into the piston between the two fluid chambers. The fluid flows freely though the passages until the magnetic field is energized. When the magnetic field is applied it causes the CIPs to align and increase the yield sheer of the fluid within the channels. Essentially, the fluid becomes almost the consistency of grease, which inhibits fluid motion in the passages. Those channels are the "valves" of this system. The great advantage of MF is that it can precisely change state almost instantaneously in a magnetic field. This characteristic gives the system a large damping bandwidth in a very short period of time.

So, how good is F55? Well, GM claims computer response time of 1 ms, but total system reaction times average 10 ms. At 60 mph, the system can respond in about 11 inches. The key to the shock's capability is it bandwidth as well as speed. It can go from virtually full soft to full stiff in that short period. We are now as close as ever to a real-time reactive system. In fact, there are

Internet rumors the new Z07 will be equipped with an even more advanced F55-type system. I chose the F55 for my 2007 for two reasons. 1. Heavy-duty cross-drilled brakes are included and 2. Control/ride on everyday highways. The Z51 package is a bit better in full performance cornering, but that can be attributed to the softer compound, asymmetric tread Eagle EMTs as much as anything else. However, what's more likely on the street, using 0.9gs cornering or running into unexpected bumps and holes? Look at these photos. Notice the flatter body angle in turns and the super quick response to keep those rear tires on the payment after hitting a bump at high speed. Finally, if you every go "cruising for food" (not in this club, of course), you'll really appreciate the Touring mode option of the F55 suspension rather than the fixed and stiff ride of the Z51.