Q. Are dispersants, corrosion inhibitors, viscosity improvers, seal swell agents, pour point depressants, foam inhibitors, anti wear, antioxidants, and red dye additives found in all transmission fluids?

And what do each of these additives do?

A. Automatic transmission fluid consists of base oil and a performance additive package. Since the base oil is the single component of automatic transmission fluid that is in the greatest amount (85-90%) it has a significant effect on certain properties of that transmission fluid

To be more specific, base oil has the greatest effect on viscosity, oxidation, tendency to foam and flash point. Obviously, there are other performance requirements placed on the transmission fluid not supplied by the base oil. This is where the use of all of the additives you mentioned come into play. The hardest part of producing this additive package is the combining all of these different chemistries together that perform all of the required functions of that additive without adversely affecting the performance of the other 10 to 15 additives present in the same base oil.

Some additives (like red dye) have little cross-over effect and do not create problems. Anti-wear additives, on the other hand, can drastically affect the frictional properties in the process of preventing wear. The balance between testing and formulation allow the additive chemist to blend up additive packages that do not compromise performance of that transmission fluid in the real world of day to day driving. The exact chemical compounds and amounts used in additive packages vary by additive manufacturer and are generally proprietary to them. I will try and go over the different categories and explain what the different performance categories do without boring you with a bunch of chemistry details that are only of interest to the chemists who blend the additive packages up.

Red dye – Red dye is present in ATF as a way to identify transmission fluid from other lubricants in the event of a leak. Certain European OEM's have started using automatic transmission fluids that are not red. Why this is, is a question that could be only answered by them. They have chosen to use a yellow dye to mark these fluids.

Dispersant – Dispersants are additives that help keep solid contaminants (usually used in a engine oil where combustion by-products are present) in colloidal suspension (molecules that do not settle) by forming a micelle (a molecule which can change in size without a chemical change) which prevents the formation of sludge and varnish on components. They are usually used with detergent additives designed to keep parts clean. Since automatic transmissions are sealed units and do not have the same contamination problems of engine oils, they have limited use in transmission fluid additive packages.

Corrosion inhibitors – Corrosion inhibiters are additives that protect metal surfaces from corrosion by preventing chemical attack from water, contaminants, or other additives present in the transmission fluid. We obviously conclude this means protection

from rust on steel parts but is also very important for preventing corrosion of copper alloys used in bushings, bearings and thrust washers.

Viscosity improvers – Viscosity index improvers expand the useful operating temperature range of transmission fluids. They allow low viscosities for low temperature operation while still providing adequate viscosities at operating temperatures. The active ingredients of VI improvers are organic polymers. To understand the behavior of these polymers you have to mentally visualize the polymer molecule as being curled up into a spherical shape in the oil. These spheres thicken the oil in proportion to the diameter of these spheres. The VI improvement results because the diameter depends on temperature. At low temperatures the polymer molecules curl up tightly so their ability to thicken the fluid is reduced allowing the transmission fluid to flow. At high temperatures they expand, increasing the diameter of the sphere, which enhances the thickening of the transmission fluid and provides better lubrication at higher temperatures. The end result of the use of VI improvers is increased shear stability, a very important requirement of today's and future ATF's.

Seal swell agents – Seal swell agents are added to transmission fluid to help meet the seal requirements called for by the OEM specifications. The main purpose of seals in automatic transmissions are to prevent internal leaks in the hydraulics of the transmission and prevent external leaks of the transmission fluid. Keeping dirt, water, and other contaminants out of the transmission is also performed by seals. Various synthetic elastomers are used to perform these functions. Each of these elastomers have different applications and properties, so compatibility between these different seal materials and transmission fluid is essential for long life and adequate performance. Some seals are required to swell to properly seal and prevent leakage, while others are more affected by the fluid itself and require protection from excessive softening or protection from hardening. Once again, achieving this balance is the end result of much testing and research on the part of the additive package blender and is a primary contributor to the complexity of additive package formulation. One of the greatest challenges for transmission fluid formulators today is achieving acceptable elastomer compatibility test results.

Pour point depressants – One of the greatest problems with transmission fluids are their flow properties at low temperatures. When transmission fluids are cooled, the waxes present in the transmission fluid can form crystals and precipitate (fall out) from solution . The temperature, at which wax crystals first become visible as a slight haze, or cloudiness, is called the cloud point.

As a transmission fluid is cooled below its cloud point, the wax crystals grow and start to form a structure within the transmission fluid which prevents the transmission fluid from flowing. The temperature at which the transmission fluid first appears to solidify is called its pour point.

Between the cloud point and the pour point, the viscosity increases of the transmission fluid increase quickly as the temperature decreases. Severe problems will occur in an automatic transmission if the transmission fluid temperature is below its pour point. The transmission fluid will not be able to flow to the oil pickup in the sump of the transmission as rapidly as the as the pump draws transmission fluid out of the pickup

area. This allows the pump to cavitate (pick up air not oil). When this happens, the transmission will starve for transmission fluid and will experience rapid wear or even catastrophic failure. Since synthetic base oils contain very little or no wax, it becomes obvious very quickly why they are preferred in transmission fluids for the complicated electronically controlled automatic transmissions of today. Pour point depressants lower the temperature at which pour point occurs. They disrupt the orderly growth of the wax crystals. Pour point depressants do not prevent wax from precipitating; they only affect the structure of the wax crystal that forms which allows flow at lower temperatures.

Foam inhibitors – Foam inhibitors are antifoam additives that reduce the transmission fluids tendency to foam. Foam control is critical for the satisfactory operation of the automatic transmission. As transmission fluid is pumped through the transmission, the action of the pump, converter, oil pickup and filter have a tendency to cause the aeration of the fluid, with the resulting formation of foam. Foam decreases the transmission fluids efficiency and has the potential to cause mechanical damage. The thinner fluids now in service have an even greater tendency to foam at higher temperatures as the fluid thins out and becomes the perfect medium to form the air bubbles that we call foam. This foaming can lead to low line pressures, clutch slipping and accelerated wear, poor heat transfer and pump cavitation and wear. A worst case scenario is the rise in fluid level from foaming that can cause the loss of fluid through the air vent or dipstick tube and the resulting fire that occurs as the transmission fluid spills out on to hot exhaust system of that vehicle. The foam inhibitors don't actually reduce the amount of foam per say; What they do is reduce the surface tension of the air bubbles, allowing the bubbles to collapse at an accelerated rate. Foam testing is performed for all transmission fluid specifications and is another very important property of transmission fluids for today's high tech, high performance, electronically controlled automatic transmissions.

Anti-wear – Another important function of transmission fluid is the prevention of wear. Anti-wear additives reduce the wear that results from metal parts rubbing or sliding against each other. Anti-wear additives are surface-active compounds that react with metal surfaces chemically, to produce a self-sacrificing layer of film that wears off, instead of the metal surface they are on.

The picture shown at left illustrates this point. The additive reacts with the metal to form a microscopic 'film' on metal surfaces, and when surfaces scrape, the actual metal-to-metal scraping is replaced with metal-to-additive. The additive is scraped off and instantly reforms again and again, infinitely.

For many years zinc dialkyl dithiophosphates, (ZDDP), was the choice of fluid formulators. They were cheap and effective, but bad players when it came to cross-linking at higher temperatures. The biggest drawback is what the OEM's call "Ash", which is the formation of sludge and deposits as the zinc falls out of the fluid. In recent years, zinc-free and ashless transmission fluid additive technology has replaced the use of zinc as the additive package of choice for transmission fluids formulators and OEM's.

Another important anti-wear additive of transmission fluids are *extreme pressure additives*. Under very high loads (as with planetary gear sets) metal-to-metal contact can cause scuffing, adhesive wear and even welding in severe cases. Extreme pressure

additives react with metal surfaces under high pressure, high temperature conditions to form a protective surface film. This protective film will wear instead of the metal surface. Both anti-wear and extreme pressure additives contain sulfur and phosphorus to accomplish this protection.

Anti-oxidants – Anti-oxidants are part of the additive package used to formulate automatic transmission fluid. Their purpose is to lengthen fluid life, permit high temperature tolerance and prevent the formation of sludge and varnish. These additives control oxidation by deactivating chains that start the oxidation that leads to sludge and varnish.