The Role of ZDDP (Zinc) in Traditional Engine Oils

In order to understand the role of ZDDP (zinc dialkyldithiophosphate), the best place to start is to explain what it contributes to the overall formulation.

The compound’s main function is as an anti-wear additive. Sulphur and phosphorous are elements within the compound and it’s their effect that provides wear protection. The main part of any lubricant, the base oil, which in the case of traditional products is mineral oil, produces a film designed to keep mechanical components separated; this process prevents metal-to-metal contact and therefore stops wear from taking place. This is successfully achieved in areas such as the bearings. When they are in motion an oil film develops that keeps journals and bearings apart. However, there are lubrication regimes, where the force applied between components, does not generate a strong film, but actually ruptures, potentially allowing metal-to-metal contact to take place. One of these areas would be cams and followers, for example. Although there is rotational movement, a cam lobe’s profile is tapered towards one end and a whipping effect when in motion can break the protective oil film. This is where ZDDP comes in. Under these conditions, the sulphur and phosphorous react with the metal surface, to produce a very hard chemical layer. Now, under these conditions, the metal components are separated by a chemical film, that stops wear from taking place. This compound is also useful in other parts of the engine such as valve guides, rings (as they change direction), sprockets, bearings starting from rest (before a film is generated), etc. Basically, anywhere an oil film may be ruptured or interrupted, ZDDP steps in.

The next thing to define is what level of ZDDP is enough. This will be defined by engine testing, used to screen and develop performance levels, such API CC or ACEA A3, etc. A test engine is built from pristine components that have all been catalogued by size, weight or appearance. After a test has been run (this varies depending on the specification), the components are catalogued again and any changes in the original data is noted and conclusions reached. If an engine component wears, it loses weight, because it is losing metal. The amount of acceptable wear that takes place can be tailored by an adequate amount of ZDDP in the formulation of the oil. This process of evaluation has been carried out for decades and the vast amount of data generated has provided formulators a base line level of acceptable ZDDP that provides good all round anti-wear protection.

The level of anti-wear performance can be varied above this base line depending on service intervals, workloads, etc. Of course, within the text above, we are referring to traditional internal combustion engines. Today, there are alternatives to ZDDP, as certain modern after-treatment devices will not tolerate high levels. These are fitted to the latest designs in order to comply with ever more stringent emissions legislation.

As far as Morris Lubricants is concerned, traditional products such as Golden Film SAE 20W/50 are formulated against well tried and tested specifications that were based on a good acceptable level of anti-wear performance. To
quantify this, we have a minimum Zinc content of 0.05% by weight in our traditional products. This may not seem very high, but you must remember we operating at the molecular level. In the microscopic world there is more than enough to protect the most vulnerable engine components.

(Prepared by A.Hill, Morris Lubricants, 27.1.2012)