

# **BOUNDARY FILM LUBRICATION THROUGH ADVANCED HALOGENATION TECHNIQUES: OXIRANE ACID SCAVENGING AND ORGANO-METALLIC SUBSTITUTION**

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Steel Shield Technologies' mechanism of operation is based upon Tribology methods that improve lubricity and load carrying capacity by improving surface characteristics and creating a stable chemical, corrosion controlled halide-based boundary film. Steel Shield's active components react with each other and the contacting asperities of the metallic surfaces to provide five mechanisms of improvement.

1. Advanced chemical boundary film formation through reactive chemical bonding.
2. Ring opening, oxirane acid scavenging and advanced corrosion inhibition.
3. Organo-metallic substitution of surface metal and free radical reactionaries.
4. Improved surface smoothness and rolling out of irregular contacting asperities.
5. Re-conditioning and molecular reconstruction of the original contacting metal surfaces.

The process of advanced boundary film formation is accomplished with an advanced combination of halogens that are controlled and rendered non-corrosive to the base metals of the system and pose no threat to the ozone layer or waste oil recovery systems due to their origins and long chain molecular lengths. These halogens initially react under thermal conditions with the organo-metallic reagents to form surface attaching compounds, thereby limiting and controlling the formation of halides from the base metals themselves. These surface attaching reagents or "electro-negative compounds" seek out and affix themselves to the lower surface areas referred to as micro-pores and fissures, as all metals are crystalline in structure and exhibit a lattice type matrix. This complex process also incorporates Van der Waal forces and dipole-dipole surface reactions. During this process, surface lapping and asperity (*irregular microscopic contacting and opposing surfaces*) roll-out is also achieved, yielding improved spread characteristics of the surfaces themselves. Due to the increase of film strength by the filling of the micro-pores and fissures, along with thermal modification of the asperities, the resulting effect is a gradual rolling out or flattening of the metal asperities rather than a breaking off or chip-away process, which would create metallic debris in the lubricant leading to abrasive wear from wear metal particles. The resulting improvement in the opposing metal surfaces further increases the fluid film strength, which is dependent on the degree of surface roughness and viscosity.

Viscosity, however, is a lesser consideration when incorporating boundary additives or halogenation techniques.

In general, boundary friction and wear consists of two components, a shear or adhesion component and a plowing or deformation component. Considering the following equation:

$$F_s = S A_r$$

Where  $F_s$  is the shear component, which predominates except when asperities sink too deeply into a boundary lubricant film or a soft opposing surface. When movement or sliding occurs, the shear friction force depends on the shear resistance per unit area,  $S$ , of any "boundary film" in the real load-supporting area between asperities. Dividing by the load,  $W$  gives the shear contribution to the friction coefficient, becoming independent of total load and apparent area of contact:

$$f_s = S * A_r / W = S / P_p \text{ or } S / P_e$$

The boundary film shear resistance,  $S$ , is assumed equal to the plastic flow shear stress,  $T_p$ , of an ideal elastic, plastic solid. Such a solid gives shear stress independent of strain and strain rate at strains sufficiently large enough to cause plastic flow. The conditions that produce the "glass transition" from liquid to plastic-like behavior are dependent on the viscosity of the material at normal temperatures and pressures and the variation of viscosity with temperature and pressure. In other words, glass transition depends strongly on chemical composition.

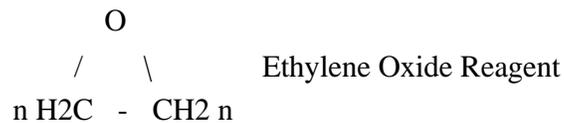
These results show that liquid lubricants act like plastic solids in the films between asperities. Therefore,  $S = T_p$  in the previous equation and the friction coefficient is  $T_p/P_p$  or  $T_p/P_e$ . Since  $T_p$  is a weak function of temperature and pressure, and  $P_p$  or  $P_e$  are independent of apparent contact load, the frictional coefficient for a given combination of lubricant and sliding surfaces tends to be independent of operating conditions.

Elasto-hydrodynamic lubrication (ELH) on an asperity scale deposits film material between sliding surfaces in "micro-rheodynamic" (micro-RHD) lubrication. As one surface slides, each asperity carries with it an aggregation of SST additive. Sufficient pressure and temperature is developed within the film to elastically deform the asperity and to force the extreme pressure reagent between the surfaces or into the micro-pores and fissures. During this time, high thermal conditions involving pressure and asperity contacts initiate a re-conditioning of the surfaces utilizing the existing oil to quench and cool the surfaces in the same process. A thermal restructuring of these asperity contact areas creates a deviation from the normal crystalline structure of the metal, expanding it into an austenitic crystalline pattern, which is more evenly structured and allows the SST additive to bond to the actual lattice of the metal, endowing it with new and unique properties upon cooling.

Organo-metallic substitution is a technique developed and designed to inhibit the process of halide formation from the base metals of the system under reaction. For example, instead of the halogen reacting with the iron in the system to form iron halides, a boundary surface salt, it reacts with a reagent having very similar properties to the iron atom itself, thereby forming an organo-metallic complex without scavenging the target metal surface itself, and depleting the metal in a chemically corrosive wear syndrome.

The process is very similar or analogous to the saponification of organo-metallic compounds in the manufacturing of greases. During this reaction or saponification,

compounds react at a certain catalytic temperature and exchange characteristic components to form new compounds. These new chemical compounds are then used to aid in a boundary regime by providing an added protection to the actual surfaces being lubricated. Ring opening oxirane acid scavenging and corrosion inhibition is another chemical technique used to neutralize acids and inhibit oxidation and corrosion. This technique involves the use of specifically engineered complex ethylene oxide; oxirane rings, that possess reactive reagents which will cause a cleavage of the ring when encountering acids or strong alkaline. These reactions occur in the presence of both anionic- and cationic-type catalysts. Anionic catalysts can include alkoxide ions, hydroxides, metal oxides, and some organo-metallic derivatives while Lewis acids and protonic reagents initiate cationic reactions.



The lubricity, load carrying capacity, surface improvement, and wear reduction are greatly improved while corrosive aspects of halogenation are virtually eliminated.

#### References:

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