Lubricants for Safety, Environment and Disaster Prevention

1. Introduction

Until now, companies have conducted compliance activities focusing on quality-related matters. However, in recent years, matters that are not related to quality and that companies must observe have increased, for example, regarding environment and industrial safety and health. As example incidents at works, waste oil gets into waste water and leaks to the sea and hot scales fly into a grease pit in the rolling process, starting a small fire (grease is a semi-solid lubricant consisting of lubricating oil and a thickener. A thickener in 3D network structure retains lubricating oil (liquid) so as to maintain the semi-solid state). Companies are requested to further work to secure safety, protect environments, and prevent disasters. If a company causes environmental pollution or fire, it deeply affects human life and also the company in question is held responsible for any damage to people living in the neighborhood and for society. Accordingly, thorough measures are required.

Under these circumstances, there are increasing demands for lubricant products used for equipment at works to be safe and environment friendly and to prevent disasters. Nippon Steel Chemical & Material Co., Ltd. has developed lubricants that satisfy such needs. This paper introduces three products of Nippon Steel Chemical & Material: Urea grease to prevent fire spread, environment-friendly fatty acid ester fire resistant fluid, and water-glycol fire resistant fluid as products for safety, environment protection, and disaster prevention.

2. Urea Grease to Prevent Fire Spread

There are various causes that start fires at works and as an example, hot scales hitting a grease pit ignite and the fire spreads. Usually, grease leaked from bearings and waste oil pans, etc., is cleaned and removed. However, grease sometimes accumulates and thereby grease to prevent fire spread is available as a highly safe grease product that, even if it ignites, prevents fires from spreading and minimizes the damage. As grease to prevent fire spread, several manufacturers are selling lithium grease to prevent fire spread for which lithium thickeners are used.[1, 2)]

Lithium salt is used to manufacture lithium grease and also used to manufacture lithium-ion batteries (LIBs) that are used as battery chargers for EVs, etc. As the demand for EVs and mobile batteries has increased in recent years, the balance between supply and demand has been upset and the price of lithium salt has increased. Consequently, the price of lithium grease has also risen. Nowadays, the prices of some grease types exceed that of urea grease that was more expensive compared with lithium grease as the performance of urea grease was higher. Although the price of lithium salt is now lower than that at the time of its peak thanks to recovery of the balance between supply and demand, lithium salt is still expensive.

Under these circumstances, Nippon Steel Chemical & Material developed urea grease to prevent fire spread ahead of other companies in Japan. Urea grease with properties to prevent fire spread is manufactured by blending nonmetallic additives into a high-viscosity base oil. Urea grease to prevent fire spread also has consistency stability (“consistency” refers to the number showing the hardness of grease), water wash resistance, and plugging resistance (difficulty of grease to clog), which are required for the application for roller bearings (**Table 1**). The grease to prevent fire spread has been designed such that it can exhibit its lubrication performance in any environment, such as at high temperatures and in water spraying environments and automatic lubrication systems.

Due to the aforementioned properties, urea grease to prevent fire spread is adopted in hot rolling processes. According to chronological data on changes in the consistency after grease has been applied, even when grease contains a water content of approximately 30%, the consistency grade is the same. The data shows that there is little change in the consistency when water content gets in. In addition, wear diagnosis through ferrography analysis found no abnormal wear on the lubrication surface and thus the grease is contributing to both disaster prevention and stable operations.

3. Fire Resistant Fluid

If mineral hydraulic oil leaks from hydraulic equipment used near high-heat sources at works, there is the risk of a fire starting. To prevent fires, fire resistant fluid must be selected for such equipment. As fire resistant fluids, there are fatty acid ester oil and phosphate oil (synthetic oils) as well as water-glycol oil and emulsion oil (water-based oils). Phosphate oil is expensive and there is concern that it may release poisonous gas during burning. The issue with emulsion oil is that it requires a complicated preservation and management procedure so as to prevent contamination with bacteria. Accordingly, in recent years, fatty acid ester and water-glycol oils have been widely used. This chapter introduces high-functionality environment-friendly fatty acid ester fire resistant fluid and water-glycol fire resistant fluid that Nippon Steel Chemical & Material developed in anticipation of stable operations of hydraulic equipment and extension of service life of oils, in addition to flame retardancy.

Table 1 Performance comparison of grease to prevent fire spread

Products	Development	Conventional
Thickener	Urea	Lithium
Heat resistance	◎	△
Roll stability (10% water)	○	○
Water wash resistance	◎	○
Pumpability	◎	◎
Lubricity*1	◎	○

Classification: ◎ very good ○ good △ average

*1 Comprehensive evaluation of heat resistance, water wash resistance, and roll stability

3.1 Environment-friendly fatty acid ester fire resistant fluid

Although fatty acid ester oil is less fire resistant than water-glycol and emulsion oils, its biodegradability is superior and thereby the risk of damaging environments when leaked is lower. In addition, its wear resistance is higher and it can thereby suppress wear of hydraulic equipment (**Table 2**). The performance of fatty acid ester oil is greatly affected by the molecular structure and quality of the base oil and additive blending techniques.[3)]

For example, oil for which the quality of the base oil is poor tends to oxidize and deteriorate and deteriorated oil substances adhere to the sliding sections, which may cause the control valves to malfunction or may wear the cylinders abnormally. In addition, fatty acid ester oil itself tends to stick on metal surfaces and some anti-wear additives may not work sufficiently, which may accelerate wear conversely.

For SHINLUBE™ EFR (hereinafter "EFR") developed by Nippon Steel Chemical & Material, highly-refined base oil is used and carefully selected additives are blended in a balance such that they do not hinder the wear resistance. Compared with other products, EFR's influence (chemical oxygen demand (COD)) on the water quality when it leaked is smaller, its biodegradability is more superior, and it has higher wear resistance (**Table 3**). EFR is widely used, for example, in steel plate production and hot and cold rolling processes.

Regarding the use of fatty acid ester oil, if a large amount of water gets in oil, the performance of the main component (fatty acid ester) may deteriorate due to hydrolysis and thereby measures to prevent water from getting in are important. In addition, compared with other fire resistant fluids, if fatty acid ester oil is exposed to high temperatures for an extended period of time, the properties and conditions may change due to oxidation degradation, so the oil temperature needs to be carefully managed.

3.2 Water-glycol fire resistant fluid

Among fire resistant fluids, water-glycol oil has the most excellent flame retardancy because it does not burn as long as it contains a certain amount of water. The main components are water, water-soluble polymer, and glycol and they are for flame retardancy, higher viscosity, and anti-freezing, respectively. The other performance is secured by additives and thereby the performance is greatly affected by additive blending techniques as is the case with fatty acid ester oil.

For example, to suppress wear of pumps and cylinders, etc., the selection of an anti-wear additive is important. However, the main components (water, water-soluble polymer, and glycol) are highly polar substances and thereby they may electrochemically hinder the anti-wear additive from adhering to the sliding surfaces, which may hinder the additive from fully demonstrating its wear resistance property. In addition, the molecular weight of water-soluble polymer becomes low due to oxidation degradation or polymer shearing, which decreases the dynamic viscosity of the hydraulic oil. Accordingly, the oil must be replaced with a new one. To minimize the replacement frequency, appropriate additives need to be selected to secure oxidation stability.

Nippon Steel Corporation and Nippon Steel Chemical & Material jointly developed SHINLUBE™ WG Fluid M46 (hereinafter, "WG Fluid M46"). For WG Fluid M46, additives that would tend to form films on metal surfaces were carefully selected so as to suppress wear of pumps even for high-pressure hydraulic equipment; additives that would not deteriorate much per se were also carefully selected so as to prevent the hydraulic oil from oxidizing. The product has been improved through many years.[4)] As a result, high wear resistance and oxidation stability were realized (**Table 4**) and the frequency of alkalinity maintenance and management was reduced. WG Fluid M46 is widely used in high-fire risk processes, such as

Table 2 Characteristics of fire resistant hydraulic fluid

Type	Synthetic		Hydrous		Mineral oil
	Fatty acid ester	Phosphate ester	Water-glycol	Emulsion (WO)	
Flame resistance	△～○	○	◎	◎	×
Environmental suitability*1	◎	△	×	○	○
Wear resistance	◎	◎	○	△	○
Maintainability	○	○	△	×	○
Cost	○	△	○	◎	◎

Classification: ◎ very good ○ good △ average × poor

*1 Comprehensive evaluation of wastewater treatability and environmental impact (COD) in the event of an oil leak
Reference: COD of water glycol is 450 000 ppm

Table 3 Environmental suitability and wear resistance of EFR

Product		EFR (VG46)	Other A (VG56)	Other B (VG56)
Impact on water quality	COD*1	< 1 000 ppm	240 000 ppm	25 000 ppm
Wear resistance	Pump wear*2	18 mg	287 mg	42 mg

*1 COD of 1 g of liquid oil dispersed in 100 ml of pure water

*2 Wear of cam ring and vane after vane pump test (13.7 MPa, 100 h)

Table 4 Wear resistance and oxidation stability of WG Fluid M46

Product		WG Fluid M46	Other A	Other B
Wear resistance	Pump wear*1	31 mg	48 mg	1 105 mg
Oxidation stability	RPVOT life span*2	> 1 200 min.	300 min.	150 min.

*1 Wear of cam ring and vane after vane pump test (17.5 MPa, 100 h)

*2 120°C, copper catalyst impregnation

processing involving blast furnaces and converters and continuous casting and hot rolling processes.

When water-glycol oil is used, water content and alkalinity maintenance and management are required to retain the flame retardancy and rustproofing property.

4. Conclusion

This paper introduced the urea grease to prevent fire spread, environment-friendly fatty acid ester fire resistant fluid (EFR), and water-glycol fire resistant fluid (WG Fluid M46) that satisfy the needs for safety, environment friendliness, and disaster prevention at works. We hope that the application of these products will contribute to equipment safety and stable operations.

References

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