DOVERLUBE™ NCL-2

Phosphorus-based EP/Lubricant Additive

Proprietary, non-chlorinated lubrication additive containing non-halogenated extreme Pressure (EP) and anti-wear additives.

Doverlube™ NCL-2 is based on phosphorous chemistry and a novel chemical principle; unlike other non-chlorinated additives, it does not rely on viscosity to perform as an EP additive.

The additive is compatible with naphthenic oil and can be made compatible with paraffinic oil by adding petroleum sulphonate or other couplers.

Doverlube™ NCL-2 is non-corrosive to both ferrous and non-ferrous surfaces.

It is extremely effective when used to replace conventional chlorinated additives in low-to heavy-duty metalworking fluids.

Typical Properties

Property	Typical Result
Appearance	Transparent, dark brown fluid
Odor	Mild, fatty
Viscosity, SUS @ 100°F	10000
Viscosity, SUS @ 210°F	540
Specific Gravity @ 50°C	0.98
Color, Gardner	11+
Flash Point, °F (C.O.C.)	450
Phosphorous (%)	3.0
Acid number, mgKOH/g	150

PERFORMANCE EVALUATION DATA

1.

Corrosion Tests	
Test	**Result**
Copper corrosion (3 hours @ 150°C)	1A
Q-Panel stain	No stain

The Q-Panel stain test was run by coating two panels with the additives and pairing them together with paper clips before placing them in a 100°C oven for 18 hours. The panels coated with 60% chlorinated paraffin were stained after six hours.

2.

Falex Pin and Vee Block EP Performance				
% Additives	0.25	2.0	3.0	5.0
Failure Loads (pounds)				
Doverlube™ NCL-2	1250	3000	no failure	4000
60% chlorinated paraffin	750	1500	4250	no failure
Commercial A (competitive, non-chlorinated additive)	1500	1500	1500	1250

3.

Falex Torque Data at 3% Weight									
Load (Pounds x 100)	5	10	15	20	25	30	35	40	45
Failure Loads (pounds)									
Doverlube™ NCL-2	4	12	20	29	34	30	45	54	-
60% chlorinated paraffin	11	25	29	34	42	51	60	70	-
Commercial A	5	13	20	-	-	-	-	-	-

Falex EP data in Charts 1, 2 and 3 show the EP performance of **Doverlube™ NCL-2** and the chlorinated paraffin were proportional to concentration, while the Commercial A additive was not. These data indicate **Doverlube™ NCL-2** performs similarly to chlorinated paraffin and chemically reacts with a metallic surface to provide its EP properties at much higher loads.

PERFORMANCE EVALUATION DATA (continued)

4. Four-Ball Weld (EP) and Wear

Additives	Weight %	Four-Ball Wear		
		Wear (mm)	LWI	Weld (kg)
60% chlorinated paraffin	3.0	0.7	26	200
Doverlube™ NCL-2	3.0	0.4	35	250

AISI E-5211 steel balls were used. LWI is Load Wear Index; a higher number indicates better wear protection.

5. Tapping Torque Test

Additives	% Tapping Torque Efficiency
60% Chlorinated Paraffin	100
Doverlube™ NCL-2	92

The Tapping Torque Test was designed to evaluate the performance of a cutting fluid. Four-ball EP indicated true EP characteristics while the Tapping Torque Test involved both EP and friction reduction, with different steels and loading mechanisms.

A 60% chlorinated paraffin in 100 SUS naphthenic oil at 3% by weight concentration was used as a reference fluid, and **Doverlube™ NCL-2** was used at the same concentration as a tested fluid. The tap bit was made of high-speed M1 tool steel and the nut blanks were made of 4140 steel.

During tapping operations all torques were recorded. The percent tapping efficiency was calculated as average reference torque reading, divided by the average tested torque reading, times 100.

6. SLT Drawbead Test

Additives	SLT Number
60% Chlorinated Paraffin	198
Doverlube™ NCL-2	184

PERFORMANCE EVALUATION DATA (continued)

7.

Drawbead Data vs. Concentration		
Concentration (Weight)	60% Chlorinated Paraffin	Doverlube NCL-2
1%	208	200
3%	298	185
5%	187	187

The SLT Drawbead Test was designed to evaluate a drawing or stamping compound. It is run with 3% by weight additives in 100 SUS naphthenic oil. The results are calculated as the unitless number expressing the minimum pulling force required to pull a metal strip (5.1 cm x 45.7 cm x 0.8 cm) a distance of 12.7 cm through a stationary bead die. A lower number indicates a more efficient D & S lubricant.

RECOMMENDED FORMULATION

Generally, a lesser or equal proportion of Doverlube NCL-2 can be used to replace chlorinated paraffin in an oil-based formulation. Both naphthenic and paraffinic oils can be used. If paraffinic oil is used, about half to equal percents of petroleum sulphonate or other coupling agents to Doverlube NCL-2 are needed to make the oil mixture compatible. Sulfur and amine containing additives appear beneficial. Amine additives can be added to partially neutralize **Doverlube™ NCL-2.**

Doverlube™ NCL-2 is non-corrosive to both ferrous and non-ferrous surfaces. **Doverlube™ NCL-2** is based on natural chemistry and can exhibit titer at lower temperatures. To reverse this, heat with mixing until titer crystals fully solubilize.

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