



LubriSilk[®] Biodegradable Synthetic Grease

BORON
CLS **B**OND™



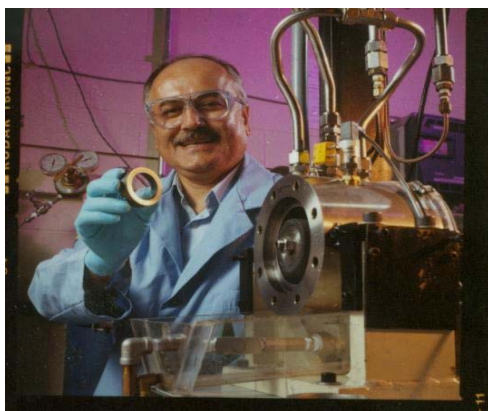
The Science of Friction Reduction



Background

The Boron CLS Bond™ line of advanced lubrication formulations (over 20) result from tribological research at Argonne National Laboratories, a U.S. Department of Energy facility. Dr. Ali Erdemir discovered that hydrated boron through a patented process forms an almost permanent and self-replenishing bond to any metal alloy creating a near frictionless surface. The friction coefficient is under 0.01. The result is an 80% reduction in surface friction a 90% reduction in component wear, the elimination of corrosion as well as a Timken extreme pressure agent.

U.S. Patent #5,431,830
Owned by ARCH Development Corporation, Argonne, Illinois U.S.A.

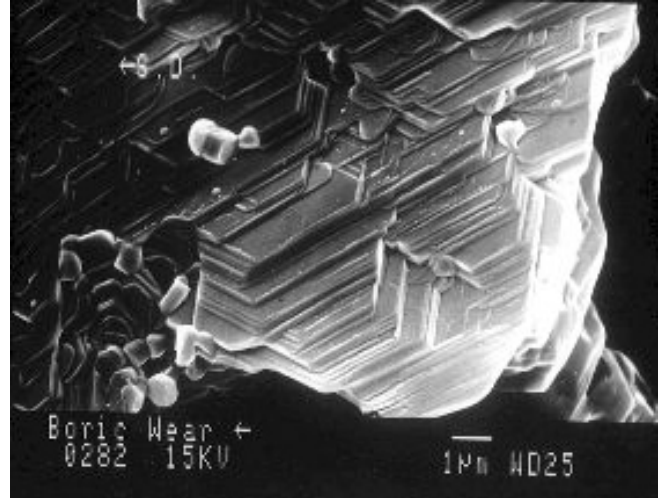


Dr. Ali Erdemir, Developer



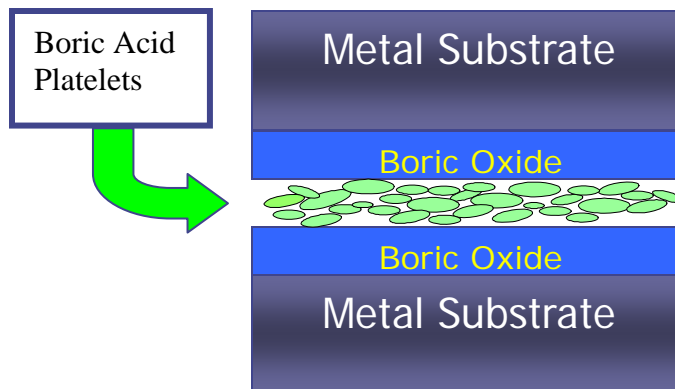
The Boron CLS Bond® Technology

Boron CLS Bond® is based on the intricate crystal lattice structure (CLS) of the hydrated boron molecules. That lattice structure allows the layers of hydrated boron particles to slide virtually friction-free over each other, like the playing cards in a fresh deck, while retaining awesome strength. The ultrafine sub-micron particles of hydrated boron reach every metal surface and crevice, lubricating with superior slipperiness as they chemically bond with the host material.



How it Works

- Boric acid is introduced to a metallic substrate in the presence of water vapor. Interaction between the substrate, the water (H_2O) and Boric Acid (H_3BO_3) forms a continuously self-replenishing film of boric oxide (B_2O_3) that bonds to the substrate, forming a corrosion-resistant barrier.
- The boric oxide spontaneously reacts with the air, replenishing the boric acid. The boric acid molecules form into crystal platelets, each of which is a triclinic lattice of molecules strongly bound together by macromolecular covalent bonds (see microscopic photo above).
- Aligned by the mechanical motion of the substrate, the platelets form stacked layers with very small (0.318 nm) spaces between. As a result, the inter-platelet layers are bound by weak "van der Waals" forces, allowing a very low coefficient of friction.

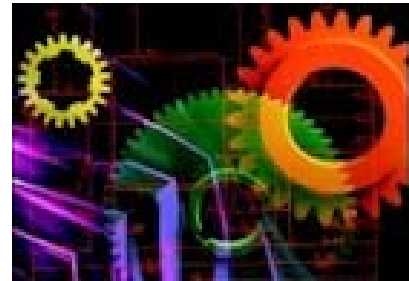




Technology Inventor:
United States Department of Energy, Argonne National Laboratory



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LUBRISILK[®] Biodegradable Synthetic Grease

DESCRIPTION

LubriSilk[®] High Performance PAO Grease, with *Boron CLS Bond*[®], is designed for extreme pressure and extreme temperature applications, formulated to provide maximum lubricity, wear reduction, extreme pressure agent (EP) and corrosion protection in heavy equipment, industry, manufacturing, extreme environments and marine applications. The highest Timken rating of 90%+ translates to a surface friction coefficient under 0.01 (80% reduction in friction and a 90% reduction wear). The water washout is 1.9% allowing exposure to extreme environments without failure. The active chemical process creates a permanent micro layer of extremely low friction Crystal Lattice Structure (CLS) that become part of the metallic surfaces,. LubriSilk[®] Grease is highly adhesive, waterproof and non-staining. This revolutionary chemistry was developed at Argonne National Laboratories, one of Americas leading research institutions.

LubriSilk[®] Grease is certified under Ospar Commission-HOCNF (Harmonized Offshore Chemical Notification Format) CLASSIFICATION: “Yellow” rating for Norway meaning that LubriSilk[®] grease is biodegradable, bioaccumulation-potential-free and non-toxic to life. The HOCNF “yellow” classification meets the strictest requirements in the world for use in marine and waterway environments while offering the foremost protection of components.

APPLICATIONS:

Applications include ‘O’ rings, bearings, gears, valves, universal joints, electric motor bearings, wheel bearings, pump bearings, heavy equipment, industrial, commercial fleet, railroad tracks, racing , off shore oil rigs, marina, drilling equipment, cables, chains or wherever the elimination of corrosion and a low friction coefficient is required.



SPECIFICATIONS

Color.....	Translucent white
Base Fluid.....	PAO #6 Durasyn® synthetic
Thickeners.....	Fumed Silica
NLGI No's.....	#00, #0, #1, #2, #3
Oil Viscosity SUS @ 210F.....	24
Dropping Point.....	None
Flash Point.....	435 F
Pour Point F.....	-10
Corrosion (100 hours).....	in 5% salt spray no rust
Solids.....	Boron Variants
Conradson Carbon %.....	.001
Water Washout % Loss.....	1.9%
Timken OK Load, Lbs.	90 +, no Timken failure
CF – Valve, ASTM G99-95 @ 50n.....	0.03 CF
Scar Value.....	0.69mm
Dielectric Strength, KV/M.....	30
D.O.T.	Non-Regulated
V.O.C.	None
Biodegradable.....	Yes >65% within 60 days
Non-toxic.....	Yes
Friction Coefficient.....	under 0.01
Fastener Torque tension.....	0.057 coefficient
H ₂ S Inhibitor	Yes

Over greasing solution

90% of bearing life is lost both to under greasing and over greasing. When over greased the temperature will rise, damaging carbon will build up and the grease may also break down. LubriSilk® grease formulated with Boron CLS Bond™ protects against over greasing due to the boric oxide covalent bond with the host metal alloy. Carbon build up is also eliminated. LubriSilk® grease may be introduced into the system without prior cleaning due to its chemical neutrality. Eventually the old grease will be replaced.



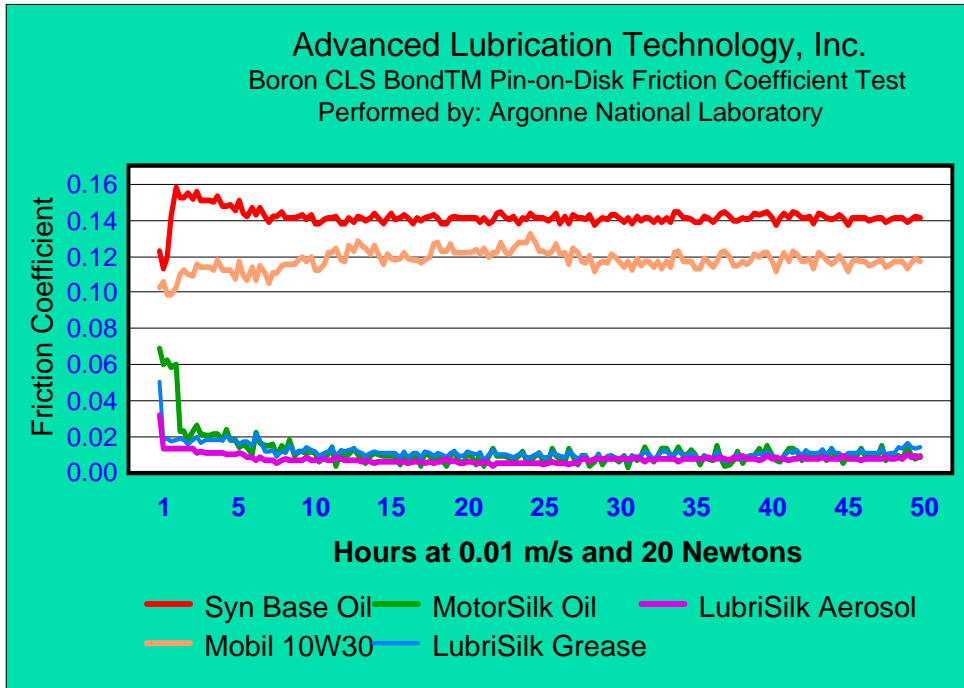
Grease Comparison

ASTM Test Results	Lithium	Calcium Sulfanate Grease		CLS Boric Acid PAO Base
	Complex	1	2	
	Grease			
Additive-commercial ZN/P/S	Yes	No	No	No
General EP/AW additives	Yes	Yes	Yes	No
HOCNF Certified	NO	NO	NO	Yes
Dropping point	312	>316	>316	None
Coefficient of friction value	0.13	X	X	>0.01
Scar value	X	X	X	0.69
Water washout %	13.6%	68.6%	5.4%	1.9%
Timken OK load pounds	35	60	70	90+
Inherently Biodegradable	No	No	No	Yes
Corrosion (100) hours	X	X	X	No Rust
Thickener	Lithium	CS	CS	Fumed Silica

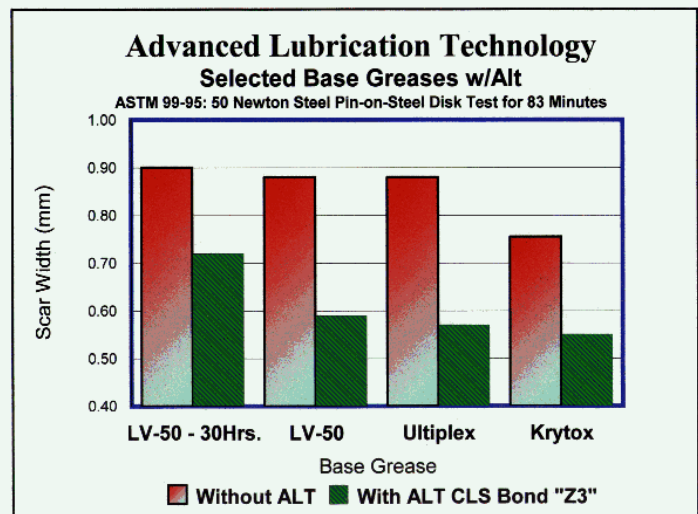
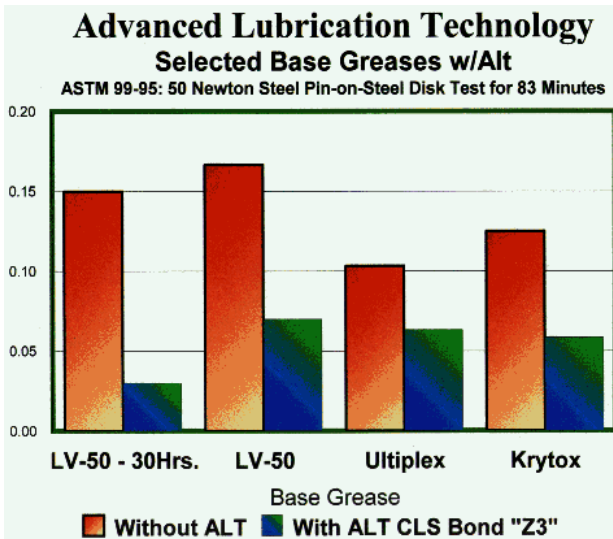
Lubricant additives historically contain graphite, chlorine, molybdenum, sulfonates and zinc/phosphorus compounds that do not chemically bond to metal surfaces, and were either toxic or produced toxic byproducts and/or corrosive acids. Boron CLS Bond™'s use of biodegradable hydrogen orthoborate (boric acid) eliminates or outperforms these additives and allows it to meet the most stringent government standards and mandates worldwide.



Lowest Friction Coefficient under 0.01



Scar Width





OSPAR Commission
for the Protection of the Marine Environment
of the North-East Atlantic

Harmonized Offshore Chemical Notification Format

Harmonised Offshore Chemical Notification Format. Short version

Producer/Importer: **ProNor AS**
 TradeName: **PROSILK CLS BOND#3 Smørefett** VerNo: **2** VerDate: **24.07.2007** ExpireDate:
 Function: **Drilling Lubricants**
 PhysicalForm: **Liquid** Odour: **Mild** SolubilityWater: **kg/m3** pH saturated: Hazard Categories:
 Colour: **Off White** Sol.WaterTemp **°C** Hazard Symbols:
 Sol.WaterScale: **Insoluble**

SubstanceName	CAS No	Mol Weight	Weight %		Aquatic Toxicity						Bioaccumulation		Biodegradation		
			Concentr. range	Norm. Conc.	Algae	Crustac.	Fish		Sediment reworker		LogPow Avg *	MethodBioacc	BioDeg % **	MethodBiodeg	Category §
					Skelctone mg/l	Acartia t mg/l	Scophth mg/l	Cyprind mg/l	Coroph mg/kg	Abra alba mg/kg					
Preparation			100	100,00											
PAO	151006-63-2	717	60 - 100	66,67	3265	3200	3274		1513		0,0000	N/A	49	OECD 306	
Fumed Silica	67762-90-7		10 - 30	16,67	3090	3200	3296		984		-3,0001	N/A	100	N/A	
Boric acid	10043-35-3	62	10 - 30	16,67	260	870	100,8		1515		-3,0001	N/A	100	N/A	

* Default value for Organic substance = 6,0001 ** Default value for Organic subst. = 0,0001 % § 200 = Water, 201 = PLONOR, 1 = Hormone disturbing, 2 = Env. toxicant, 3 = BioDeg < 20% and logPow >= 5, 4 = BioDeg < 20% and ToxC50 <= 10.
 Default value for Inorganic substance = -3,0001 Default value for Inorganic subst. = 99,9999 % Categories 6, 7, 8, 99 (no ecotox data) and 100 (other) are not calculated in Supplier-CHEMS.

Section 1.7 - Contamination (table is shown if one or more contaminants are present)

Comments: _____

CHARM _____ Bruksområde _____

Til utfasing _____ Dosering _____

Ospar Commission-HOCNF CLASSIFICATION: “Yellow” rating for Norway meaning that LubriSilk™ grease is biodegradable, bioaccumulation-potential-free and non toxic to life. The HOCNF “yellow” classification.

Ospar’s strategy for offshore platforms and marine vessels sets the objective of preventing and eliminating pollution and taking the necessary measures to protect the maritime area against the adverse effects of offshore activities so as to safeguard human health and of conserving marine ecosystems and, when practicable, restoring marine areas which have been adversely affected. LubriSilk® Grease is the only certified grease in the EU to meet the strictest requirements in the world for biodegradability and non-toxicity.



NON
TOXIC





Bolt Science Limited was founded in 1992 with the intention of becoming the recognized worldwide quality provider of independent technical expertise in bolted joint technology. Our clients include many of the major engineering organizations of the world.



Bolt Science Limited was contacted by Evergreen to perform torque testing and determine torque values using LubriSilk[®] grease as required by the North Sea Oil Platforms prior its use of bolts and piping. A 44 page report was the result and may be acquired by contacting us.

Key areas in bolt science is achieving the proper torque for preload. For the North Sea it is vital to achieve the greatest torque value which is achieved by a low coefficient, other areas of importance is corrosion for which the boric acid in LubriSilk[®] eliminates.

Abstract from the torque value report

Test Series	Average coefficient of friction	Minimum coefficient of friction	Maximum coefficient of friction
Tests with grease applied 7 days prior to the tests	0.067	0.060	0.077
Tests with grease applied just prior to testing	0.057	0.050	0.063

Conclusion/Discussion

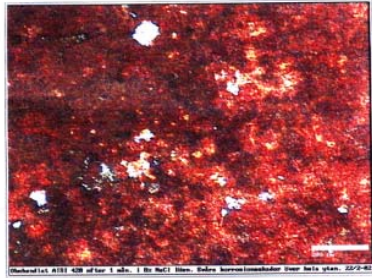
The Lubrisilk grease tested exhibits an exceptionally low coefficient of friction. Lithium grease exhibits a coefficient in friction of the order of 0.13, molybdenum disulfide grease typically 0.09 compared to an average of 0.060 for the Lubrisilk grease after it had been on the fastener for seven days. The repeated tightening tests indicated that the Lubrisilk grease keeps the surfaces lubricated and is not displaced by the high pressures in the threads and under the nut face. Using the Lubrisilk grease resulted in the coefficient of friction reducing with re-use. It is uncertain why this should occur. The coefficient of friction for unlubricated fasteners generally increases with re-use. For unlubricated electro-zinc plated fasteners, the coefficient of friction typically doubles (from 0.15 to 0.3) after five re-tightenings. The placing of grease onto the fasteners several days prior to the test did not result in the coefficient of friction reducing as compared to fasteners being greased just prior to the test. The average value of the coefficient of friction was slightly lower with fasteners greased just prior to testing compared to those fasteners that had grease on them for several days. *William Eccles, Bolt Science Limited*

Standard Comparison Corrosion Test using Metal in a Corrosive Environment

The boric oxide coating eliminates moisture and oxygen from the metal surface

manuel@micromy.com

Without the boric oxide coating



With the boric oxide coating

Corrosion maintenance costs represent a significant portion of operating budgets in most industrial sectors, particularly where aging structures/plant is involved. Modern approaches to maintenance management (sometimes referred to as profit centered maintenance) are designed to minimize these costs and to improve reliability and availability of plant and equipment. In this context, maintenance activities are treated as an investment and not as an organizational liability.



BOTH TEST COUPONS WERE DIPPED FOR 10 SECONDS IN FLUID, DRIED 15 HOURS, THEN SALT SPRAY, THEN PHOTO AFTER 6 HOURS. ALL AT 72 DEG. F.

In Field Use Examples of LubriSilk® Grease



Several years ago Wellstream of Florida evaluated LubriSilk® No.2 grease for use in the manufacturing of extraction tubes for recovery of gas and oil at offshore platforms. Test showed that use of LubriSilk® greases increased the useful life of the tubes by a factor of 6 times. It was then specified as the only grease acceptable for use in the manufacture of these tubes. Subsequently the parent company in the United Kingdom evaluated it against a number of competitively supplied products for expanded use in grease applications on the platforms themselves and are using LubriSilk® greases exclusively.

HALLIBURTON

The head engineer of Jet Research , a division of Halliburton contacted us to solve a corrosion problem they have with gravitation bearings used in offshore oil exploration and in close proximity to explosives. We sent them boric acid lubricant. After one month the engineer came back pleased beyond expectation since under an electric microscope no corrosion could be viewed. Halliburton manufactures an extensive line of lubricants which could not solve this problem.

Canadian Rails success with LubriSilk® has lead to the use of #1 and #00 greases in their automatic track grease applications where grease is shot onto the insides of the rails in turns to prevent accelerated wear of the expensive curved rail sections and also to reduce fuel cost up to 7%. A surprise benefit was a six fold reduction in grease usage and the delivery of the grease spread from 1 kilometer on the tracks to 3 kilometers.



North Sea Oil Rigs Successfully Test Grease



LubriSilk® High Performance Synthetic grease has past the new **REACH standards** in Europe as readily biodegradable and non toxic for marine organisms. Tests for the North Sea Offshore Oil Rigs proved LubriSilk® grease to outperform grease from major oil companies. Presently our grease has eliminated practically two dozen greases that were in use.

Summary

The Boron CLS Bond™ solid boundary lubricant technology addresses the three major areas of lubricant challenges with one solid boundary powder: Hydrogen Orthoborate, eliminating the need for toxic corrosion inhibitors, anti-wear additives and extreme pressure agents. In each of these categories hydrated boron far outperforms in friction reduction, eliminating corrosion and a superior EP agent equal to 85% the hardness of diamonds, even exhausting the limits of the Timken test. LubriSilk® grease is in a category of its own and used worldwide solving lubrication problems where other greases fail.

