KING INDUSTRIES
SPECIALTY CHEMICALS

# Grease Additives

## *High Performance Additives and Base Stocks*

*NA-LUBE®, NA-SUL® and K-CORR®*

*King Industries, Inc.* is a leading global developer, manufacturer and marketer of additives and synthetic base stocks for the lubricant and grease industry. For many years, King Industries has been the reliable supplier of the NA-LUBE®, NA-SUL® and K-CORR® product lines. King continually develops high quality additives and base oils to fulfill the industry's needs.

The lubricating grease industry continuously requires higher performance and cost-effective products. The performance of a grease is influenced by many factors, including thickener type, base fluid, base grease manufacturing method and the type and amount of additives used. King Industries offers a broad range of additives that are used in the formulation of greases.

Additionally, King offers the industry's broadest line of synthetic alkylated naphthalene base oils and base oil modifiers under the ***NA-LUBE KR*** trade name.

# Synthetic Base Oils
# Base Oil Modifiers
# Additives for Grease

## Base Oils and Base Oil Modifiers



## Antiwear Additives



## Extreme Pressure Additives



## Antioxidants



## Rust and Corrosion Inhibitors

***NA-LUBE KR*** series of alkylated naphthalenes are synthetic fluids with outstanding thermal and thermo-oxidative stability. They exhibit excellent performance properties when used as the sole or co-base oil for grease applications. Alkylation of naphthalene is a core technology of King Industries; thus, we are able to offer customized products designed to meet our customers' demanding application requirements.

| Product | Viscosity @ 40°C |
|---|---|
| KR-015 | 114 cSt |
| NSF KR-015FG | 114 cSt |
| KR-019 | 177 cSt |
| NSF KR-029FG | 177 cSt |

*NSF = HX-1 Registered for incidental food contact*

- Imparts superior thermo-oxidative stability
- Acts as a bridging solvent - reduces opaqueness
- Requires less thickener - improves low temperature properties
- Acts as a highly effective dispersant - produces a smooth grease

***NA-LUBE KR-015***
***Neat Grease Comparison***

PAO 10 (89%)
Li-12-OH (11%)

***KR-015 (93%)***
Li-12-OH (7%)

| Formulation Parameter | *Neat Base Oil Performance in Lithium 12-OH Grease (NLGI#2)* | |
|---|---|---|
| | 89% PAO 10<br>11% Li-12-OH | 93% ***KR-015***<br>7% Li-12-OH |
| **P (60)**<br>**P (100K)**<br>**% Change** | 273<br>350<br>28 | 288<br>366<br>27 |
| **Oil Separation** | 4.1% | 2.8% |
| **Dropping Point** | 202°C | 200°C |
| **TGA** | 233°C | 304°C |

## *NA-LUBE KR-015 - For Improving Thermo-oxidative Stability*

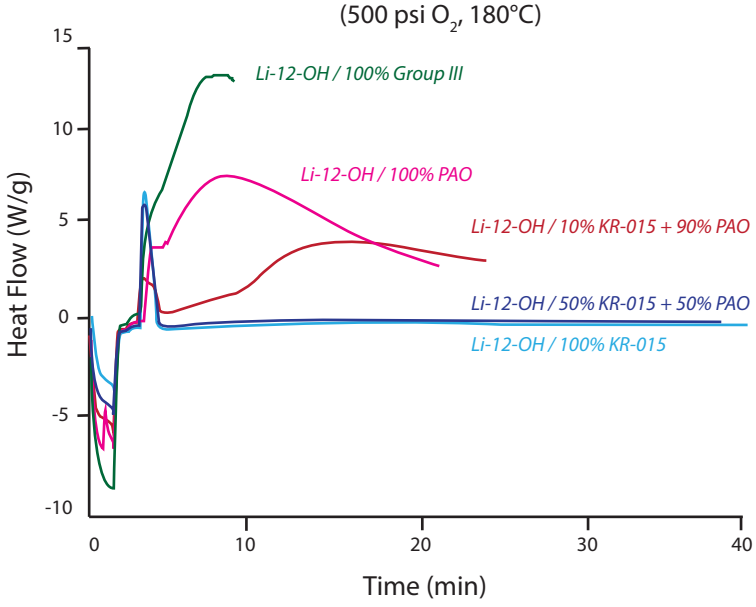
These curves compare five lithium 12-hydroxystearate greases made with different base oils and base oil blends.

Oxidation initiates almost immediately at 180°C for the greases made with Group III and PAO.

***A small introduction of alkylated naphthalene NA-LUBE KR-015 into the PAO shows immediate improvement.***

50/50 NA-LUBE KR-015 and PAO shows no oxidation after 40 minutes at 180°C under these conditions.

**PDSC - ASTM D5483**
(500 psi $O_2$, 180°C)



***NA-LUBE AW-6000*** series of ashless antiwear and extreme pressure additives is based on a variety of phosphorus, sulfur and nitrogen chemistries. If ashless systems are desired, these additives are effective alternatives to metallic phosphates. Typical treat levels are 0.5% to 2.0% by weight.

| NA-LUBE | Composition | Content %P | %N | %S | Advantages/Attributes |
|---|---|---|---|---|---|
| **AW-6110** | Amine salt of aliphatic phosphoric acid esters | 8.2 | 1.8 | -- | • Multifunctional additive with excellent anticorrosion and antiwear properties<br>• Outstanding FZG performance<br>• Light color |
| **AW-6220** | Proprietary preparation with amine phosphate | 4.5 | 5.7 | -- | • Multifunctional additive with excellent anticorrosion and antiwear properties<br>• Yellow metal deactivator functionality<br>• Light color |
| **AW-6310** | Proprietary preparation of sulfur-phosphorus-nitrogen containing chemistries | 4.2 | 3.0 | 9.1 | • Multifunctional additive with excellent anticorrosion, AW and EP properties<br>• Timken performance booster<br>• Excellent thermal stability |
| **AW-6330** | Proprietary preparation of sulfur-phosphorus chemistries | 4.5 | -- | 10.0 | • Multifunctional ashless additive<br>• Outstanding EP and AW performance<br>• Good antioxidation properties<br>• Suitable ZnDTP replacement |
| NSF **AW-6400FG** | Amine salt of aliphatic phosphoric acid esters | 8.3 | 2.4 | -- | • Compliant with FDA CFR 178.3570 up to a treat level of 0.5% by weight<br>• Multifunctional additive with excellent anticorrosion, antiwear and EP properties<br>• Light color |
| NSF **AW-6509** | Triphenyl phosphorothionate | 8.9 | -- | 9.3 | • Compliant with FDA CFR 178.3570 up to a treat level of 0.5% by weight<br>• Low coefficient of friction<br>• FZG synergy with NA-LUBE AW-6400FG |

## *Performance in Lithium 12-OH (NLGI #2)*

***NA-LUBE AW-6310*** is an ashless multifunctional additive that provides excellent rust protection to greases when tested in the presence of 5% synthetic sea water. In the study below, NA-LUBE AW-6310 is able to provide corrosion-free bearing races, as well as antiwear protection.

| Performance Tests | Base Grease | *1.5% NA-LUBE AW-6310* |
|---|---|---|
| **EMCOR Rust Test (ASTM D6138, IP 220), 5% SSW** | 3,3 | **0,0** |
| **Four Ball Wear (ASTM D4172)**<br>**1 hour, 75°C, 40 kgf, 1200 rpm, Scar Diameter (mm)** | 0.72 | **0.48** |
| **Copper Corrosion (ASTM D130, DIN 51 759)**<br>**3 hours, 100°C**<br>**3 hours, 135°C** | <br>1b<br>1b | <br>**1b**<br>**1b** |

## *Extreme Pressure Additives* — *NA-LUBE® EP Series*

***NA-LUBE EP-5000*** series of extreme pressure additives consists of light-colored, low-odor sulfurized olefins and sulfurized fatty acid esters that provide excellent extreme pressure properties. NA-LUBE EP-5210, an inactive sulfur carrier, and NA-LUBE EP-5415 are ideally suited for greases and work extremely well when combined with other extreme pressure and antiwear additives. Typical treat levels are 3.0% to 5.0% by weight.

***NA-LUBE ADTC*** is an ashless dialkyldithiocarbamate offering extreme pressure, antiwear and antioxidant properties in greases whenever heavy metals are not desired. Because of its chemical structure, NA-LUBE ADTC is ideally suited for formulating antimony-free and low ash containing EP greases. Typical treat levels are 1.0% to 5.0% by weight.

| Product | Composition | Total Sulfur | Advantages/Attributes |
|---|---|---|---|
| NSF **ADTC** | Methylene-bis-dibutyldithiocarbamate | 30% | • Multifunctional additive with extreme pressure, antiwear and antioxidant properties<br>• Good thermal stability |
| **EP-5210** | Sulfurized fatty acid ester | 10% | • Compatible with non-ferrous metals and aluminum alloys<br>• Light color, low odor |
| **EP-5415** | Sulfurized olefin and triglyceride | 15% | • Light color, low odor, low active sulfur content<br>• Environmentally friendly |
| **EP-5665** | bis-dimercaptothiodiazole derivative | 65% | • Outstanding performance in heavily loaded grease applications<br>• Excellent antiwear and antioxidant properties<br>• Compatible with ferrous and non-ferrous metals |

## *Antioxidants* — *NA-LUBE® AO Series*

***NA-LUBE AO*** series consists of liquid and solid aminic and phenolic antioxidants that are effective stabilizers for a broad range of greases. All products are ashless, non-corrosive and have excellent solubility in petroleum and synthetic base stocks. Typical treat levels are 0.2% to 1.5% by weight.

| *NA-LUBE* | Chemical Basis | Nitrogen | Form | Viscosity @ 100°C |
|---|---|---|---|---|
| **AO-130** | Dinonyl diphenylamine | 3.5% | Liquid | 17 cSt |
| NSF **AO-142** | $C_4/C_8$ diphenylamine | 4.5% | Liquid | 9 cSt |
| **AO-210** | 2,6-Di-tert-butylphenol | -- | Solid at < 36°C | -- |
| **AO-242** | Di-tert-butylphenol derivative | -- | Liquid | 5 cSt |
| NSF **ADTC** | Methylene-bis-dibutyldithiocarbamate | 6.5% | Liquid | 15 cSt |
| **AW-6330** | Ashless dithiophosphate | -- | Liquid | 2.8 cSt |

***NA-SUL*** rust and corrosion inhibitors are a broad range of high performance additives based upon dinonylnaphthalene sulfonates (DNNS). Many different NA-SUL grades are used in greases depending upon the type of thickener, the base fluid, the level of rust protection desired and the performance requirements other than corrosion protection.

| NA-SUL | Description | Attributes |
|---|---|---|
| **BSN*** | Neutral Barium Salt | General purpose, high temperature version available |
| **BSB** | Basic Barium Salt | For greases that contain acidic additives |
| **CA-1089** | Neutral Calcium Salt | General purpose and high temperature |
| **CA-50** | Basic Calcium Salt | For salt-fog protection, excellent for post-tensioning grease |
| **ZS*** | Neutral Zinc Salt | General purpose, high temperature version available |
| **420** | Sodium Complex | Designed for organo-clay grease - minimal softening |
| NSF **CA-770FG** | Neutral Calcium Salt | NSF HX-1 |

**BSN-HT and ZS-HT are offered for high temperature conditions*

***NA-SUL CA-1089*** Performance - Lithium 12-OH Grease (NLGI #2) + 0.5% NA-LUBE® AO-142

| | Distilled Water | | | 5% Synthetic Sea Water | | |
|---|---|---|---|---|---|---|
| ***NA-SUL*** | -- | **0.5% CA-*1089*** | **1.0% CA-*1089*** | -- | **1.0% CA-*1089*** | **3.0% CA-*1089*** |
| **Static Rust Test ASTM D1743/D5969** | Fail | Pass | Pass | Fail | Pass | Pass |
| **EMCOR Rust Test ASTM D6138, IP 220** | 3,4 | 1,2 | 0,0 | 4,4 | 1,1 | 0,0 |

***K-CORR*** and ***K-CORR G*** rust inhibitor systems are specifically designed to provide outstanding rust protection to greases exposed to severe salt water conditions. Test results are available in lithium 12-hydroxystearate, lithium complex, polyurea and calcium sulfonate greases with 5% and 100% synthetic sea water and 3% sodium chloride.

| K-CORR | Description | Attributes |
|---|---|---|
| 1031 | Amino Acid Derivative | Rust inhibitor and antiwear synergist |
| G-1086A | Zinc-Based | For severe salt water conditions |
| G-1107 | Ashless Chemistries | For severe conditions with AW synergy |
| NSF NF-200 | Ashless YMD | NSF HX-1 |
| SD-1223C | Polyamine | Booster for rust inhibitors, NA-LUBE AO and NA-LUBE AW |
| NF-410 | S-N Chemistry | Copper corrosion inhibitor |
| G-1340 | Proprietary Carboxylate | Medium viscosity zinc naphthenate alternative |
| G-1350 | Proprietary Carboxylate | High viscosity zinc naphthenate alternative |
| G-1360 | Proprietary Carboxylate | Low viscosity zinc naphthenate alternative |
| G-1370 | Proprietary Carboxylate | Medium viscosity zinc naphthenate alternative |

| | | | Zinc Naphthenate Replacements | | | |
|---|---|---|---|---|---|---|
| Performance Tests | -- | Zinc Naphthenate | K-CORR G-1340 | K-CORR G-1350 | K-CORR G-1360 | K-CORR G-1370 |
| **Treat Level** | 1.5% in Fully Formulated Lithium 12-OH Grease | | | | | |
| **EMCOR**<br>**ASTM D6138**<br>**3% NaCl Solution** | 4,4 | 1,1 | ***0,0*** | ***0,0*** | ***1,1*** | ***2,2**** |
| **Four Ball Wear**<br>**ASTM D2266**<br>**1 hour, 75°C, 40 kgf, 1200 rpm (mm)** | 0.65 | 0.50 | ***0.50*** | ***0.55*** | ***0.50*** | ***0.52*** |
| **PDSC**<br>**ASTM D5483**<br>**Onset Point, 180°C (min)** | 26 | 38 | ***45*** | ***49*** | ***37*** | ***48*** |
| **Grease Water Stability**<br>**DIN 51 807 Part 1**<br>**3 hours, 40°C / 90°C** | 0/1 | 0/1 | ***0/1*** | ***0/1*** | ***0/1*** | ***0/1*** |
| **Water Washout Resistance**<br>**ASTM D1264**<br>**% Loss, 40°C**<br>**% Loss, 80°C** | 1.48<br>0.90 | --<br>-- | ***0.75***<br>***0.82*** | ***0.60***<br>***0.90*** | ***1.00***<br>***0.97*** | ***0.87***<br>***1.32*** |

* May perform best in a different Li-12-OH grease

## Product Recommendations

### NA-SUL® & K-CORR® Recommendations by Grease Type

| Grease Type | Product Recommendations |
|---|---|
| **Lithium / Lithium Complex** | NA-SUL BSN, NA-SUL CA-1089, NA-SUL ZS, K-CORR G Series |
| **Aluminum Complex** | NA-SUL ZS-HT, K-CORR 1031 |
| **Calcium / Calcium Complex** | NA-SUL CA-1089, NA-SUL CA-50, K-CORR G Series |
| **Polyurea** | NA-SUL BSN, NA-SUL CA-1089, K-CORR 1031, K-CORR G-Series |
| **Organo-Clay** | NA-SUL 420 |

### NA-SUL®, K-CORR® & NA-LUBE® Recommendations by Special Condition

| Special Conditions | Product Recommendations |
|---|---|
| **Acid Neutralization** | NA-SUL BSB, NA-SUL CA-50 |
| **Ashless Systems** | K-CORR 1031, K-CORR G-1107 |
| **Elevated Temperatures, Extended Use** | NA-SUL ZS-HT, NA-SUL BSN-HT, K-CORR 1031, K-CORR G-1107 |
| **Food Grade (for H-1 Greases)** | NA-LUBE AW-6400FG, NA-LUBE AO-142, K-CORR NF-200, NA-SUL CA-770FG |
| **Multifunctionality** | NA-SUL AW-6310, NA-LUBE ADTC, NA-SUL AW-6330 |
| **Salt Spray Protection (ASTM B117)** | NA-SUL CA-50, NA-SUL CA/W1935, NA-SUL CA/W1745 |
| **Yellow Metal Protection** | K-CORR NF-200, K-CORR NF-410 |
| **Salt Water Protection (ASTM D5969 or ASTM D6138)** | K-CORR G-Series |

## Technical Service

Our technical service team is ready to assist your development of greases to meet the most demanding applications. This brochure is only a sampling of our products and capabilities. We have a modern grease test laboratory that includes ASTM, DIN and IP equipment. In addition to a series of existing test reports, we are dedicated to individualized projects. The combination of high performance additives, extensive test equipment and our ongoing communication will result in greases to meet your objectives.

## Contact Information

**www.kingindustries.com**


**Global Headquarters**
**Tech. Service, R&D, and Sales**
King Industries, Inc.
1 Science Road
Norwalk, CT 06852, USA
Phone: 1-203-866-5551

**European Tech. Sales Office**
King Industries, International
Science Park 402
1098 XH Amsterdam
The Netherlands
Phone: 31 20 723 1970

**China Sales Office**
Dalian Mingruida Technical Consulting Co., Ltd.
Building 51, 20 Shuxiang Street
Dalian, China
Phone: 86 15941108485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ISO 9001 ISO 14001 OHSAS 18001