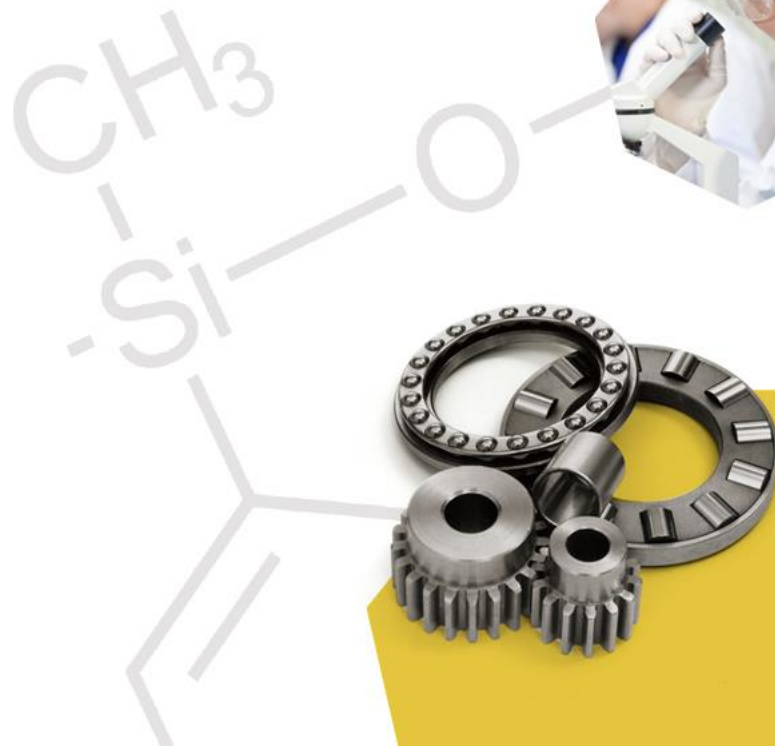


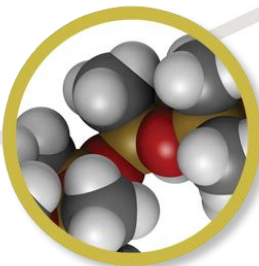


DOW CORNING

Molykote[®] G-900X Series Greases for High Temperature Applications



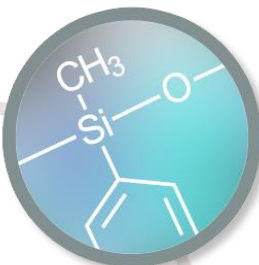
Contents



Polysiloxanes:
Structure and
Properties



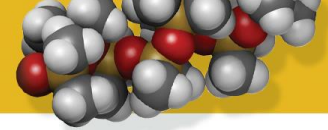
Potential
Applications



Ph/F-Copolymer
Technology and
Properties

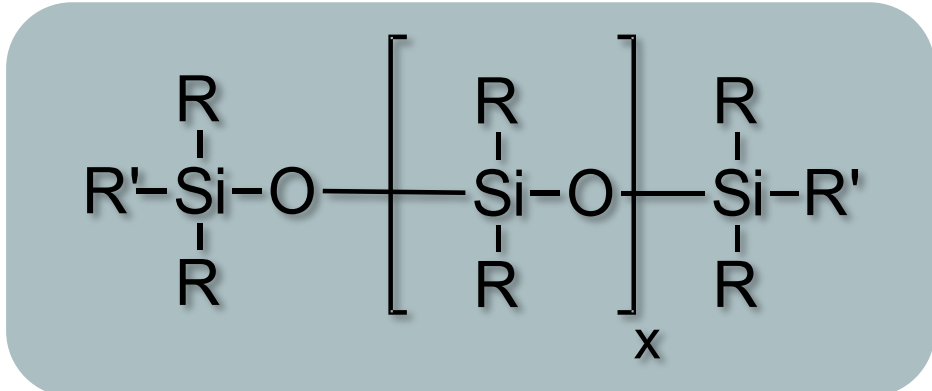


Summary



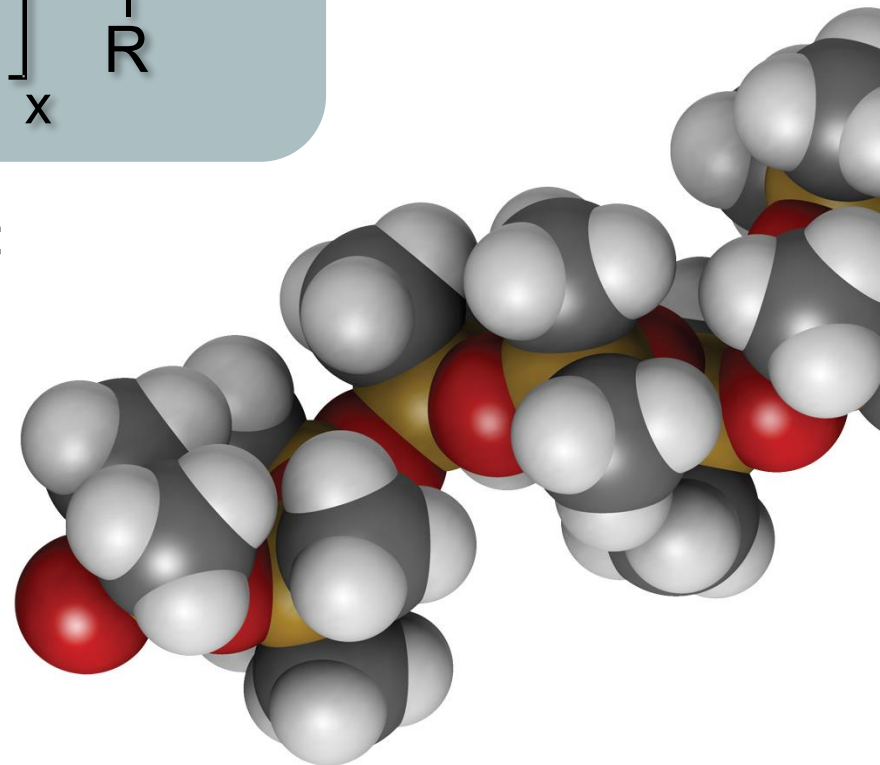
Polysiloxanes: Structure and Properties

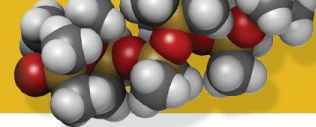
Silicone or Polysiloxanes are chain polymers with an Si-O-Si backbone:



They have some unique properties like:

- High thermal stability
- Chemically inert
- Low surface tension
- High oxidative stability
- Low vapor pressure

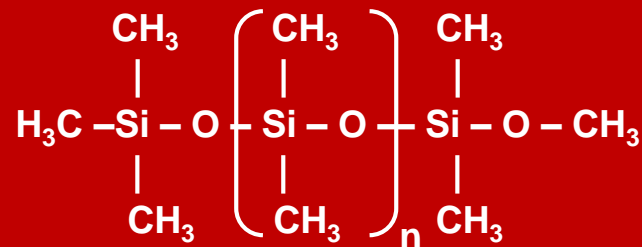




Polysiloxanes: Structure and Properties

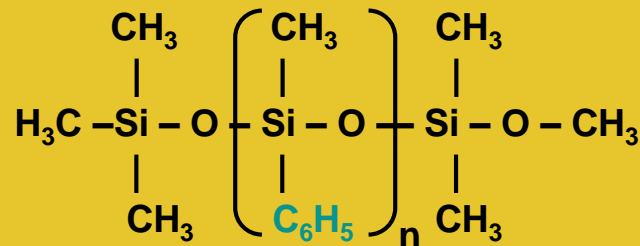
Dimethyl
Silicone
(PDMS)

“Standard” silicones



Phenyl
Methyl
Silicone
(PMPS)

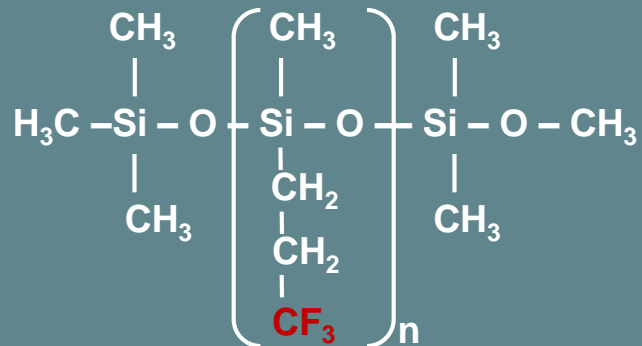
Additional thermal
and oxidation stability

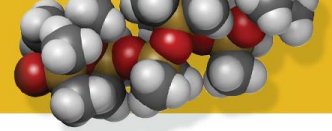


Fluoro
silicone
(FS)

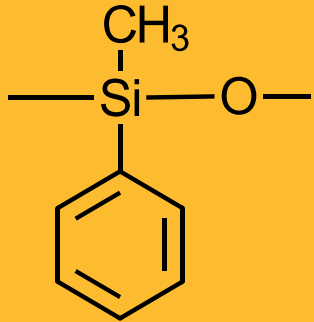
Excellent chemical
resistance

Better load-carrying capacity
and wear resistance



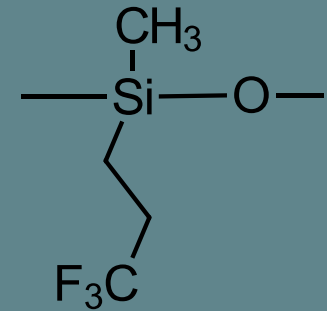


Structure of Phenyl/Fluoro Siloxane Copolymer Lubricants

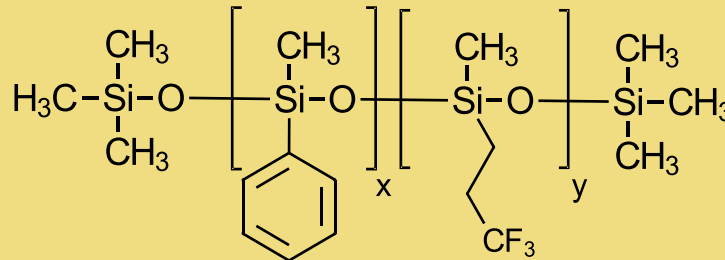


Phenyl

Different Ph/F ratio allows balance between thermal stability and wear resistance



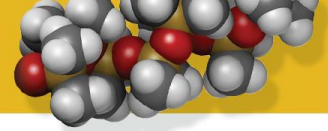
Fluoro



Phenyl/Fluoro Copolymer

Thermal stability

Wear resistance



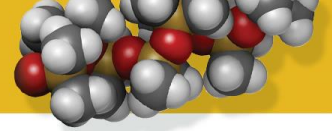
Additive Acceptance

Polysiloxane fluids have limited miscibility with additives

Fluorosiloxane fluids are immiscible with additives

Phenyl/Fluoro copolymer fluids show **good acceptance with many commercial available additives**

New lubricants using commercial available additives



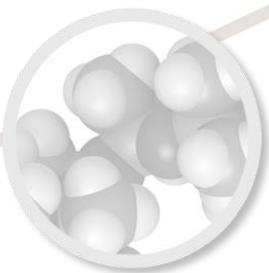
Copolymer Greases

- Greases can be prepared by using single and complex thickener systems (for example, Li and Li-complex soaps)
- Non-soap thickeners like polyurea or PTFE are also suitable to prepare copolymer greases

Grease preparation process is similar to current polysiloxane greases



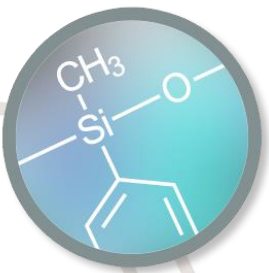
Contents



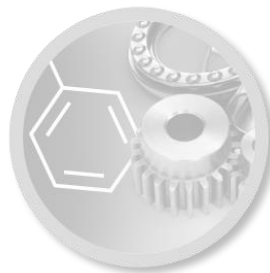
Polysiloxanes:
Structure and
Properties



Potential
Applications



Ph/F Copolymer
Technology and
Properties



Summary

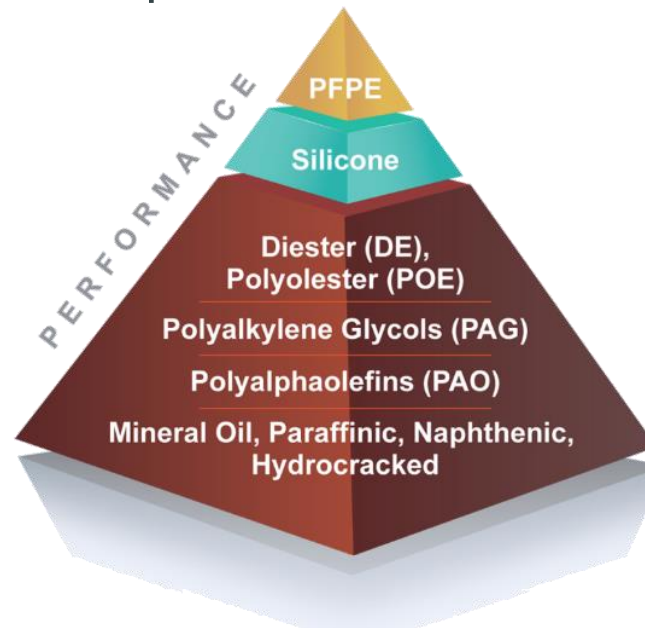




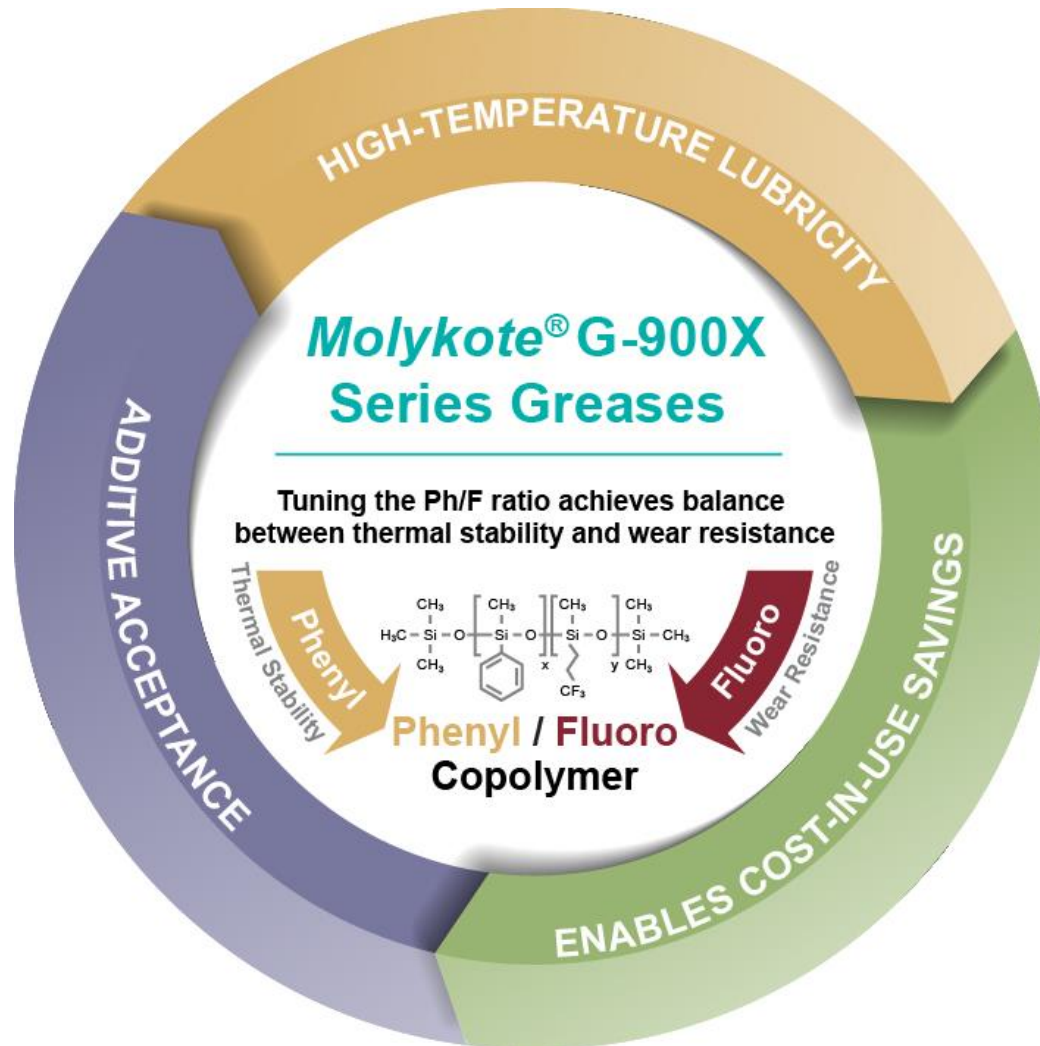
The *Molykote*[®] G-900X Series Greases Positioning

The *Molykote*[®] G-900X Series Greases are a new class of silicone lubricants with **significantly improved lubricity** and **high-temperature performance**

A **cost-attractive series of lubricants** in applications that do not require the ultimate high-temperature performance and where ester-based lubricants will be limited in temperature



Molykote® G-900X Series Greases Offering



Molykote® G-900X Series Greases offer high temperature lubricity

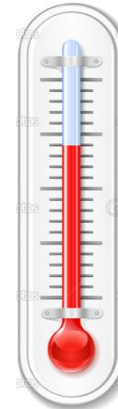


| Test Method | Norm, Specification | Silicone grease | PFPE grease 1 | PFPE grease 2 | PFPE grease 3 | Ester grease 4 | Molykote® G-9001 Grease | Molykote® G-9000 Grease |
|--|---------------------|---|---------------|---------------|---------------|----------------|--------------------------------|--------------------------------|
| Base Oil Technology | | Ph-Si | PFPE | PFPE | PFPE | Polyol-ester | Si-Copolymer | Si-Copolymer |
| High-temperature performance: FAG FE9, (6000 rpm & 1.5kN); F ₅₀ | DIN 51821 @ 220°C | not tested max service temp is 200°C | 15 h | 44 h | 42 h | Fail | 62 h | 66 h |



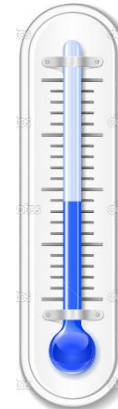
Molykote® G-900X Series Greases offer superior performance across a wide temperature range

- Running in bearing applications at **220°C**
- High dropping point (**>280°C**)
- Low bleeding at 200°C (**< 4%**)



**High
Temperature**

- Flow pressure at **-35°C**
< 1000 mbar
- Low temperature torque at **-30°C and -40°C**



**Low
Temperature**



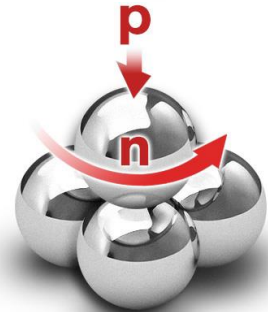
Molykote® G-900X Series Greases offer corrosion resistance

| Test Method | Norm, Specification | Silicone grease | PFPE grease 1 | PFPE grease 2 | PFPE grease 3 | Ester grease 4 | Molykote® G-9001 Grease | Molykote® G-9000 Grease |
|---|---------------------|-----------------|---------------|---------------|---------------|----------------|-------------------------|-------------------------|
| Base Oil Technology | | Ph-Si | PFPE | PFPE | PFPE | Polyol-ester | Si-Copolymer | Si-Copolymer |
| Corrosion resistance: SKF EMCOR 1 week, dest. water | DIN 51802 | 1 | 0-1 | 0 | 1-2 | 0 | 0 | 0 |





Molykote® G-900X Series Greases are a step change in lubricity compared to standard Si-technology

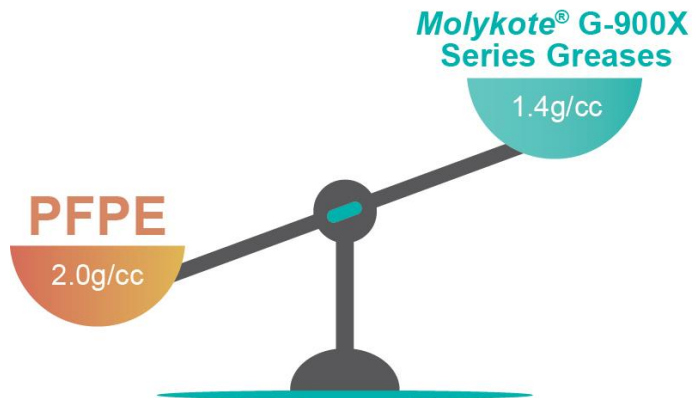


| Test Method | Norm, Specification | Silicone grease | Molykote® G-9001 Grease | Molykote® G-9000 Grease |
|--|---------------------|---|-------------------------|-------------------------|
| Base Oil Technology | | Ph-Si | Si-Copolymer | Si-Copolymer |
| High-temperature performance: FAG FE9, (6000 rpm & 1.5kN); F ₅₀ | DIN 51821 @ 220°C | not tested max service temp is 200°C | 62 h | 66 h |
| Four Ball Wear Scar | DIN 51350 Pt4 /NA | 2,61 mm | 1,18 mm | 1,18 mm |



Molykote® G-900X Series Greases offer 30% density advantage over PFPE

| Test Method | Norm, Specification | Silicone grease | PFPE grease 1 | PFPE grease 2 | PFPE grease 3 | Ester grease 4 | Molykote® G-9001 Grease | Molykote® G-9000 Grease |
|---------------------|---------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|
| Base Oil Technology | | Ph-Si | PFPE | PFPE | PFPE | Polyol-ester | Si-Copolymer | Si-Copolymer |
| Density @ at 20°C | ISO 2811 | 1,05 g/cm ³ | 1,95 g/cm ³ | 1,95 g/cm ³ | 1,95 g/cm ³ | 1,01 g/cm ³ | 1,42 g/cm ³ | 1,42 g/cm ³ |



1 kg of Ph/F Si copolymer grease provides 1.3 x more volume compared to PFPE!



Molykote® G-900X Series Greases

Performance Summary

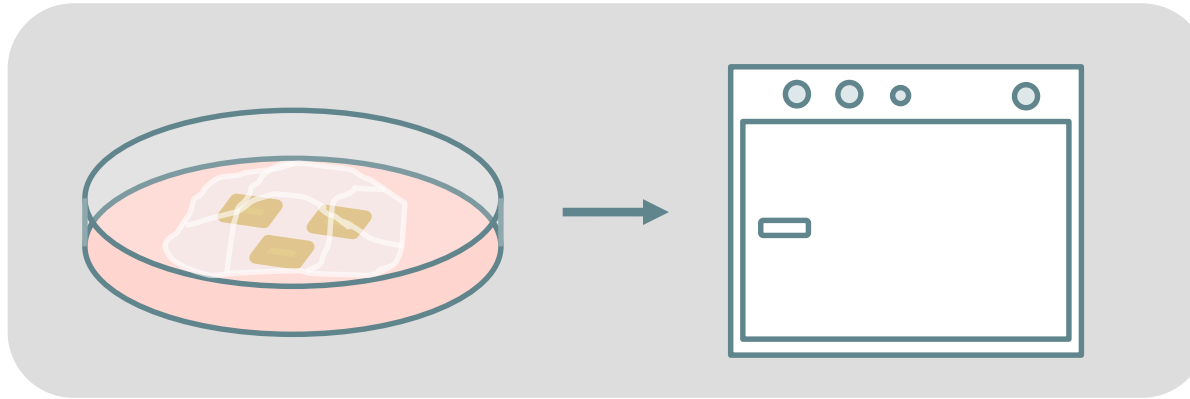


| Test Method | Norm, Specification | Silicone grease | PFPE grease 1 | PFPE grease 2 | PFPE grease 3 | Ester grease 4 | Molykote® G-9001 Grease (400 cSt) | Molykote® G-9000 Grease (650 cSt) |
|--|---------------------|--------------------------------------|------------------------|------------------------|------------------------|------------------------|-----------------------------------|-----------------------------------|
| Base Oil Technology | | Ph-Si | PFPE | PFPE | PFPE | Polyol-ester | Ph/F Si Copolymer | Ph/F Si Copolymer |
| Density @ at 20°C | ISO 2811 | 1.05 g/cm ³ | 1,95 g/cm ³ | 1,95 g/cm ³ | 1,95 g/cm ³ | 1,01 g/cm ³ | 1,42 g/cm ³ | 1,42 g/cm ³ |
| Consistency | DIN 5118 NLGI grade | NLGI 2-3 | NLGI 2 | NLGI 2 | NLGI 2 | NLGI 2-3 | NLGI 2 | NLGI 2 |
| Dropping Point | DIN | 220°C | 198°C | 169°C | 161°C | > 295°C | 285°C | 302°C |
| Flow Pressure at -40°C | Kesternich test | 1150 mbar | 1175 mbar | 700 mbar | 575 mbar | 775 mbar | 950 mbar | 1525 mbar (800 mbar @ -35°C) |
| Bleed after 24H 200°C | Fed Stan 791-321.2 | 9.59% | 8.74% | 12.28% | 10.00% | 4,50% | 3,67% | 3,19% |
| Evaporation after 24H 200°C | Fed Stan 791-321.2 | 1.75% | 0.08% | 0.08% | 0.14% | 2,44% | 0,33% | 0,36% |
| High-temperature performance: FAG FE9, (6000 rpm & 1.5kN); F ₅₀ | DIN 51821 @ 220°C | not tested max service temp is 200°C | 15 h | 43 h | 42 h | 87 h @180°C | 62 h | 66 h |
| Four Ball Wear Scar | DIN 51350 Pt4 /NA | 2,61 mm | 1,45 mm | 1,18 mm | 0,72 mm | 1,03 mm | 1,18 mm | 1,18 mm |
| Four Ball Weld Load | DIN 51350 Pt4 /NA | 1400 N | 7500 N | > 8500 N | > 7500 N | 2600 N | 2300 N | 2300 N |
| Corrosion resistance: SKF EMCOR 1week, =<1 | DIN 51802 | 1 | 0-1 | 0 | 1-2 | 0 | 0 | 0 |
| Copper Corrosion | ASTM, DC | 1b | 1a-1b | 2b | 1b (200° C) | 2c | 2b (150°C, 3h) | 2b (150°C, 3h) |



Plastic and Elastomer Compatibility

Elastomers grease-insulated kept in oven for **7 days at 80°C**



| | NBR | | EPDM | | FKM | | Si-Rubber | |
|--------------------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|
| | Weight change | Shore A change | Weight change | Shore A change | Weight change | Shore A change | Weight change | Shore A change |
| Molykote® G-9001 Grease | -1,35% | -2 | -4,79% | 5 | -0,41% | 2 | 2,59% | -1 |
| Molykote® G-9000 Grease | -1,27% | -4 | -3,20% | 3 | -0,42% | 2 | 1,89% | 0 |

Note: All elastomers are different and there are a lot of parameters influencing the compatibility. Tests with specific customer samples are recommended before application!



Plastic and Elastomer Compatibility

- Stress cracking with specimen acc. to DIN EN ISO 527-2 Type 1B, **7 days at 80°C**
- Radius of sample holder = 140 mm



| Product | POM | PA 6.6 | ABS | PC | PEEK |
|--|-------------|-------------|-------------|-------------|-------------|
| <i>Molykote</i> [®] G-9000 Grease | No cracking | No cracking | No cracking | No cracking | No cracking |

Note: All plastics are different and there are a lot of parameters influencing the compatibility. Tests with specific customer samples are recommended before application!



Paintability

Option 1: The grease is applied crosswise on the substrate and coated directly



Silicone Grease



PFPE Grease



Molykote® G-9000 Grease

Option 2: The grease will be dry-wiped off after the application and the substrate will be coated



Silicone Grease



PFPE Grease



Molykote® G-9000 Grease

Test method: acc to PV 3.10.7

Paintability



| | PDMS-Silicone/LiX Grease | PFPE/PTFE Grease | Molykote® G-9000 Grease |
|----------|---|---|--|
| Option 1 | Surface defects in the area where grease was applied; adjacent area without the defects | Surface defects in the area where grease was applied; adjacent area without the defects | No surface defects; can be coated |
| Option 2 | Surface defects in the area where grease was wiped off; adjacent area without the defects | Surface defects in the area where grease was wiped off; adjacent area without the defects | Structure difference in the area where grease was wiped off; adjacent area without the defects |

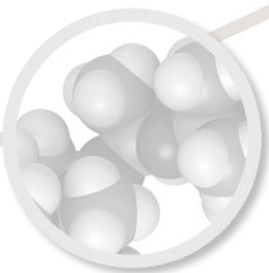
Electrical properties



| | Dielectric Strength (V/mil) | Volume Resistivity (ohm*cm) |
|--|-----------------------------|-----------------------------|
| Test method | CTM0114* | CTM0272* |
| <i>Molykote</i> [®] G-9000 Grease | 549,2 | 1.3717 E+12 |
| <i>Molykote</i> [®] G-9001 Grease | 549,2 | 9.5917 E+11 |

* CTM – Corporate Test Methods, copies of CTMs are available on request

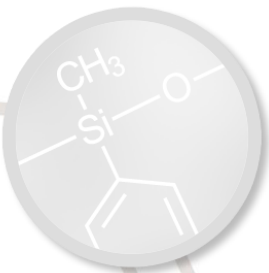
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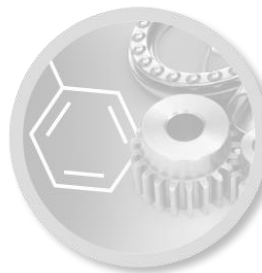
Polysiloxanes:
Structure and
Properties



Potential
Applications



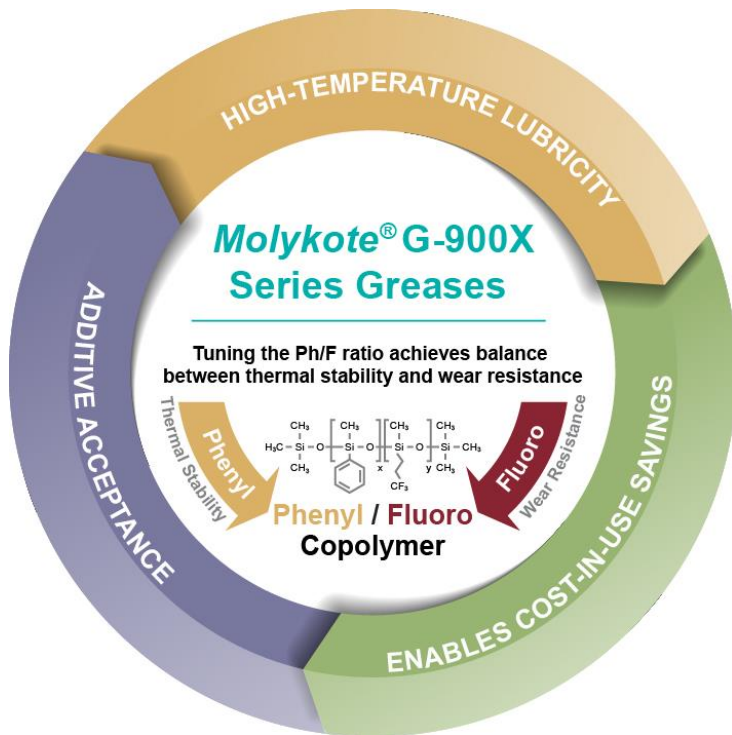
Ph/F-Copolymer
Technology and
Properties



Summary



Molykote® G-900X Series Greases are a competitive alternative to PFPE for high-temperature lubrication

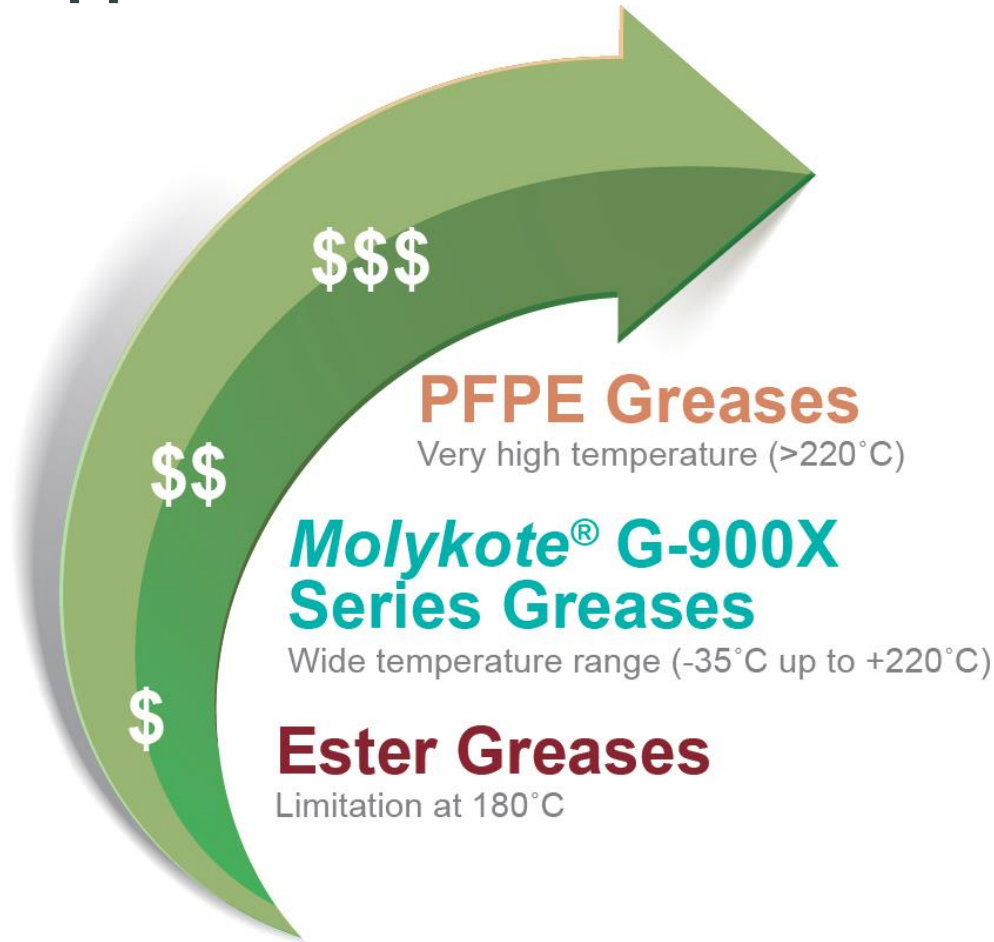


Key Features & Benefits

- Heat stability up to 220°C
- Wide service temperature range (-35°C to 220°C)
- Improved wear resistance
- Good additive acceptance
- Good plastic compatibility
- Easy cleaning
- 30% density advantage over PFPE
 - ⇒ *Cost-in-use advantage*
 - ⇒ *Light weight potential*



Molykote® G-900X Series Greases offer a cost-attractive lubrication solution for high temperature applications



Potential Applications



Auto - under the hood



Tire Molding



Bearing



Textile



Pulp & Paper



Injection Molding



Heat Treatment Furnace



Industrial Equipment



Chemical



Food Processing



Appliances



Metal Processing

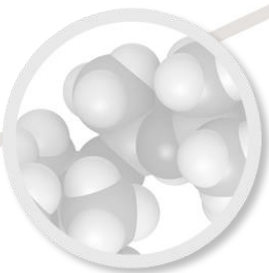


Oil & Gas



Wood Processing

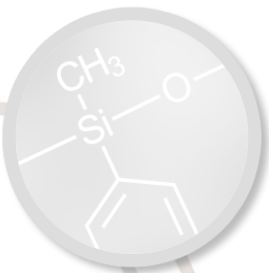
Contents



Polysiloxanes:
Structure and
Properties



Potential
Applications



Ph/F-Copolymer
Technology and
Properties



Summary



Summary

- Phenyl-/fluoro copolymer siloxane fluids are a **totally new class of lubricating polysiloxane fluids** that opens new opportunities and possibilities
- Their flexible structure allows to design fluids with **high thermal stability** and **improved wear resistance** properties
- Ph/F copolymer fluids have an improved **additive acceptance** which allows to create lubricants for a broad range of applications
- Copolymer greases can be formulated with **different kinds of thickener systems**
- A **cost-attractive series of lubricants** in applications that do not require the ultimate high-temperature performance and where ester-based lubricants will be limited in temperature



DOW CORNING

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