# Gear Lubrications

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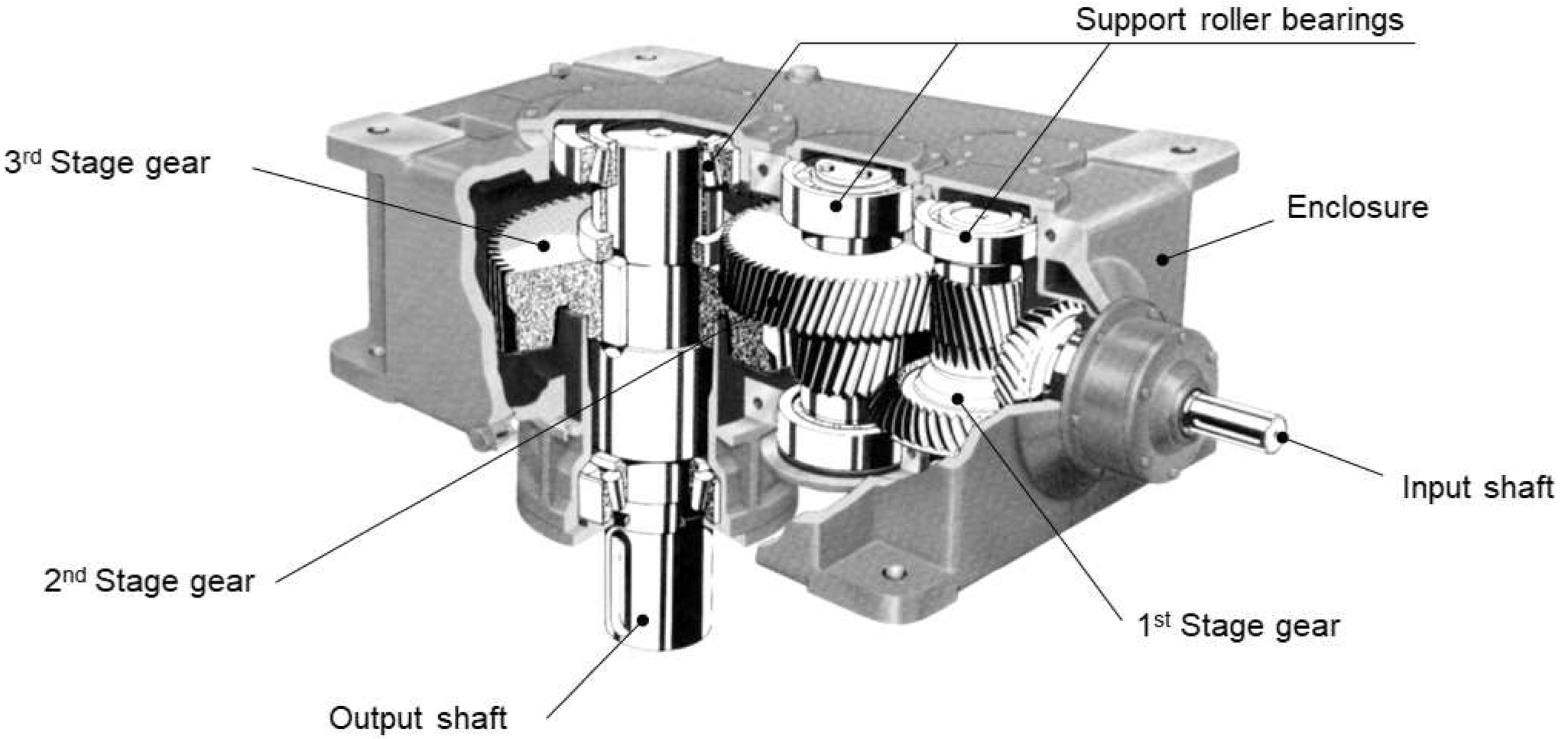
KLÜBER LUBRICATION a brand of FREUDENBERG

# Gear Transmission

**Gear** or **cogwheel** is a rotating machine part having cut teeth or, in the case of a cogwheel, inserted teeth (called cogs), which mesh with another toothed part to transmit torque.

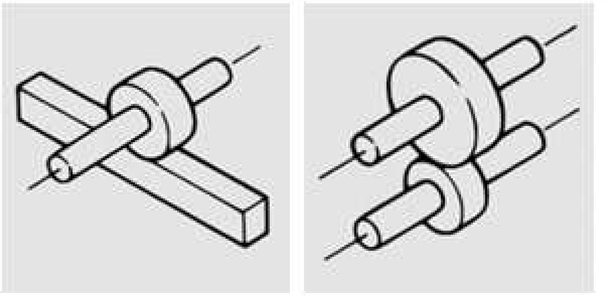
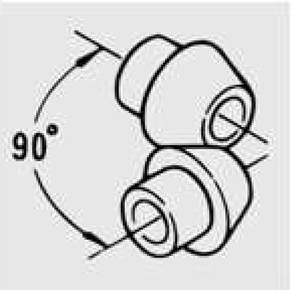
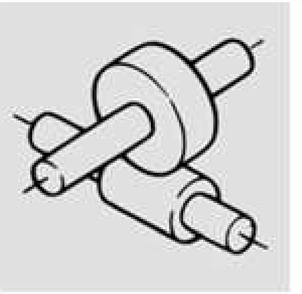
- Increase/decrease speed of rotation.
- Change amount of torque.
- Reverse the direction of rotation.
- Move rotational motion to a different axis.

# Gear Component



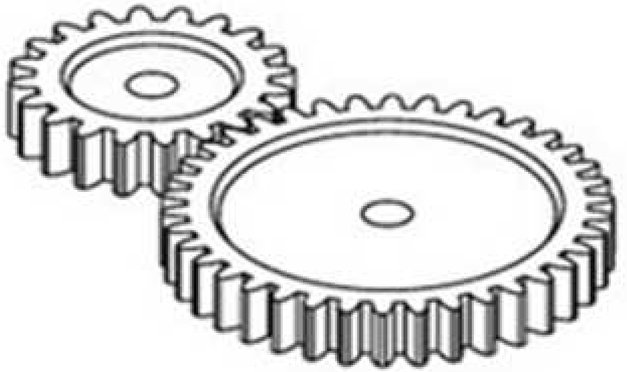
# Types of Gears

Gear Types and Axial Arrangements

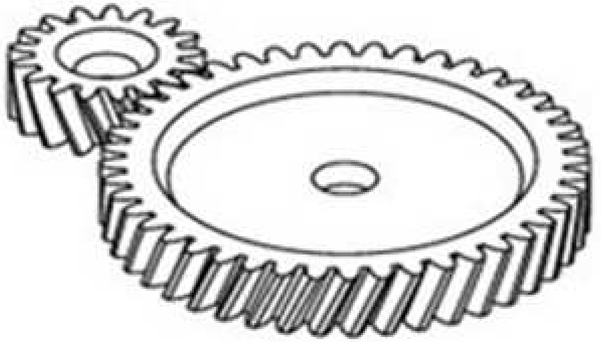
| | | |
|---|---|---|
| Parallel Axis Gears |  | Spur Gear |
| | | Helical Gear |
| | | Rack Gear |
| Intersecting Axis Gears |  | Straight Bevel Gear |
| | | Spiral Bevel Gear |
| | | Crown Gear |
| Nonparallel and Nonintersecting Axis Gears |  | Worm Gear |
| | | Hypoid Gear (Screw Bevel Gear) |
| | | Crossed Helical Gear (Screw Gear) |

# Types of Gears

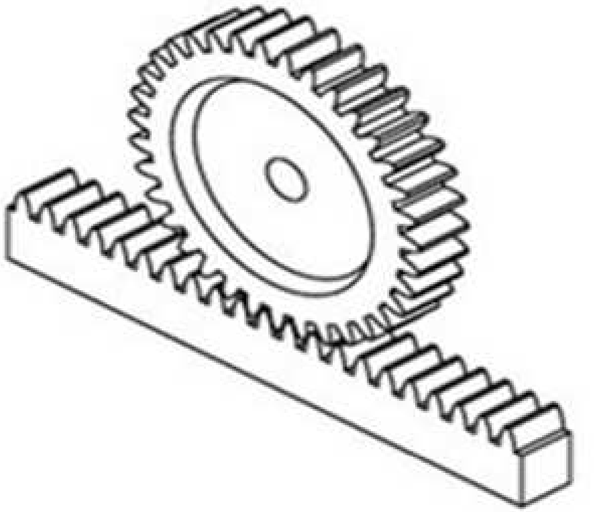
Parallel Axis Gears



Spur Gear

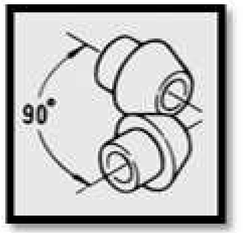


Helical Gear

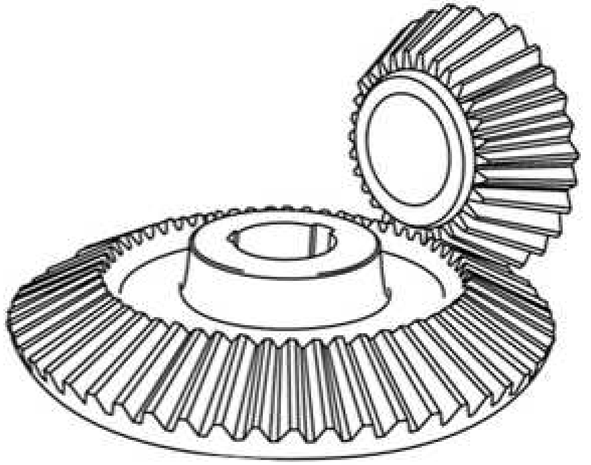


Rack Gear

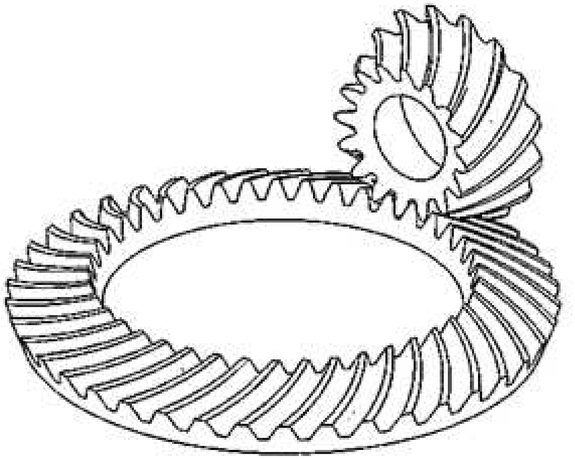
# Types of Gears



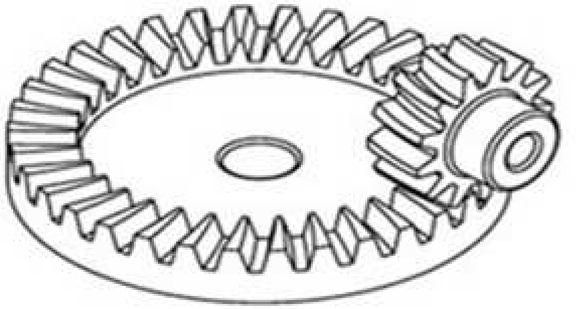

Intersecting Axis Gears



Straight Bevel Gear



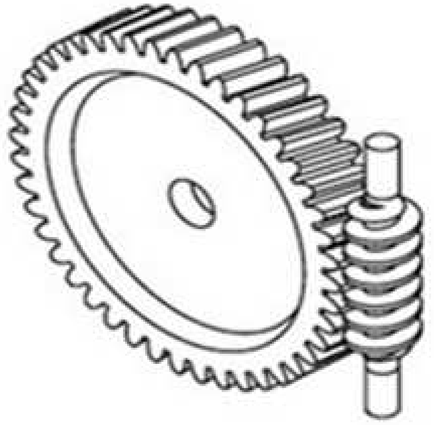
Spiral Bevel Gear



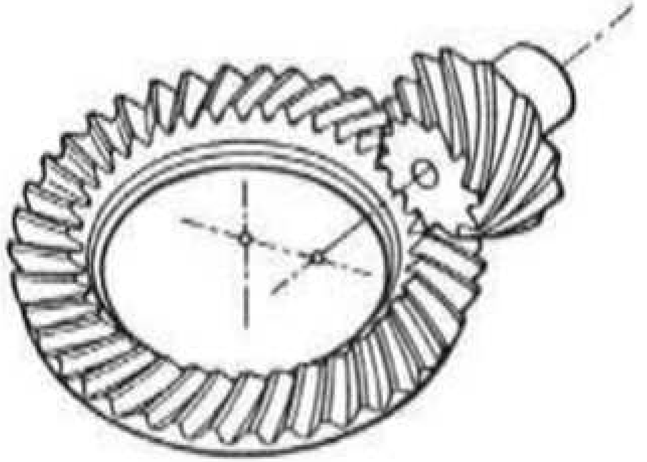
Crown Gear

# Types of Gears

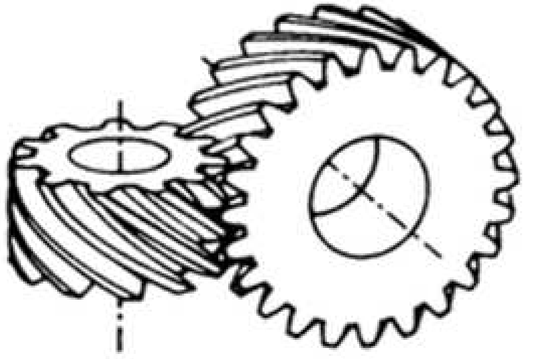
Nonparallel and Nonintersecting Axis Gears



Worm Gear

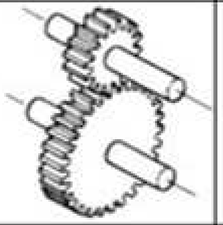
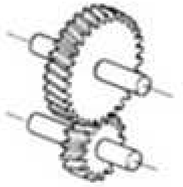
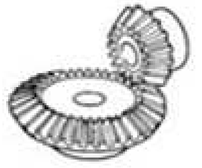
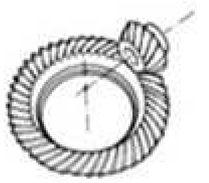
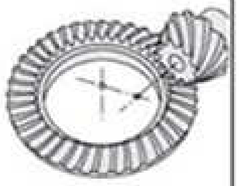


Hypoid Gear
(Screw Bevel Gear)



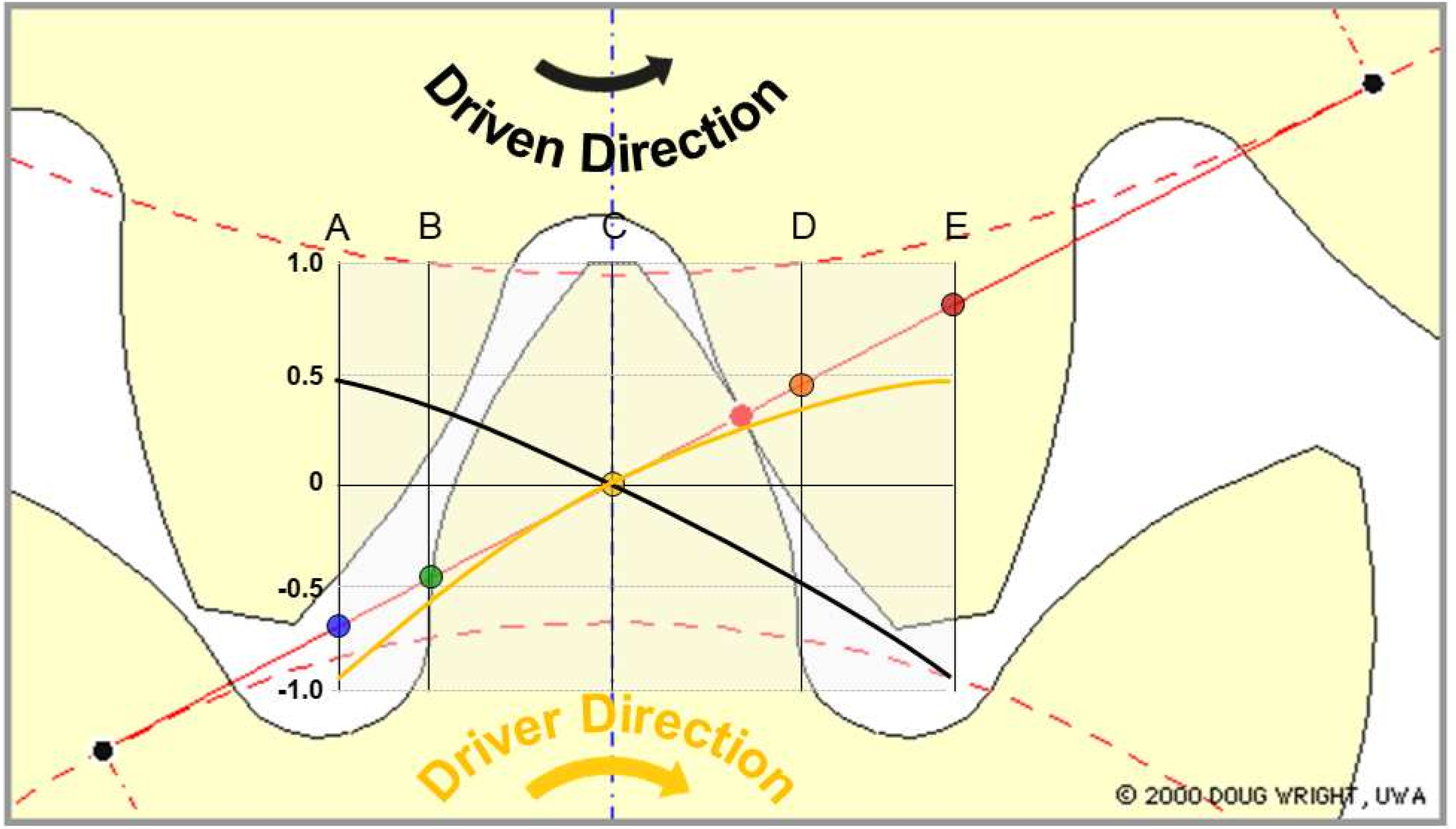
Crossed Helical Gear
(Screw Gear)

# Types of Gears

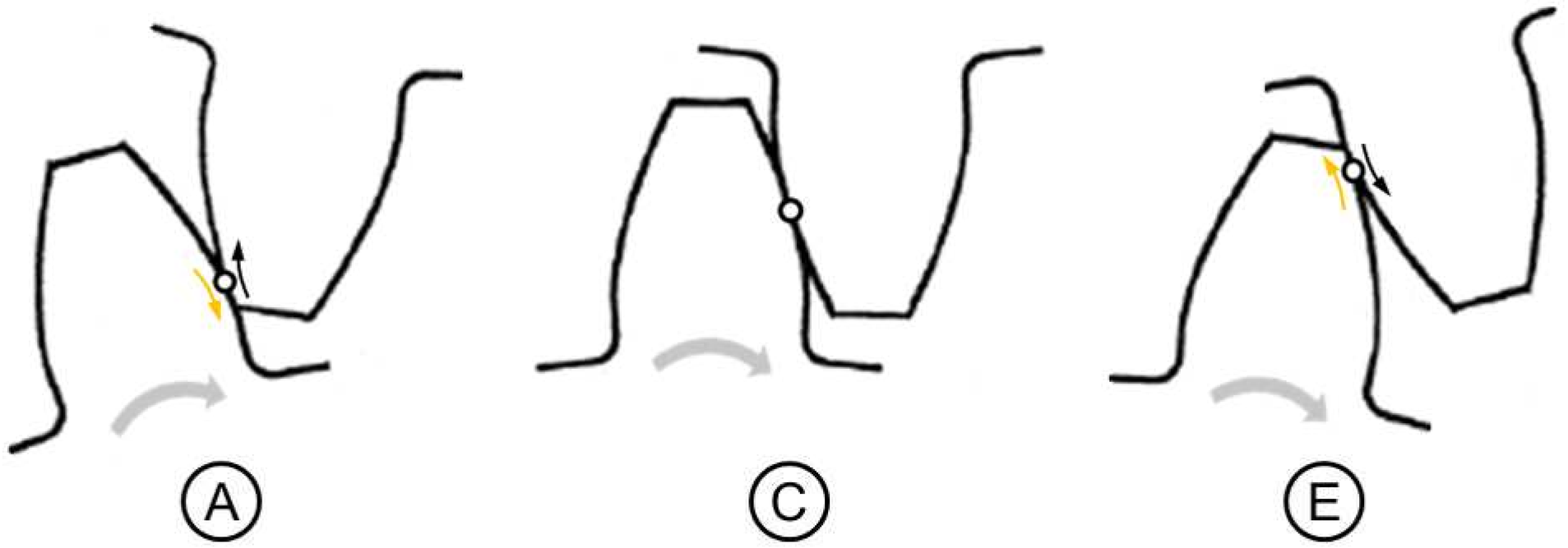
| | Spur | Helical | Bevel | | Worm | Hypoid | Screw |
|---|---|---|---|---|---|---|---|
| | | | Straight Bevel | Spiral Bevel | | | |
| Type |  |  |  |  |  |  |  |
| **Shaft Arrangement** | Parallel shaft | Parallel shaft | Intersecting shaft | Intersecting shaft | Non intersecting, non parallel shaft | Non intersecting, non parallel shaft | Non intersecting, non parallel shaft |
| **Sliding friction** | 10-30% | 10-30% | 20-40% | 20-40% | 70-100% | 60-70% | 60-70% |
| **Gear Ratio** | 1:1 to 6:1 | 3:2 to 10:1 | 3:2 to 5:1 | 3:2 to 4:1 | 5:1 to 75:1 | 10:1 to 200:1 | 10:1 to 200:1 |
| **Efficiency** | 94-98% | 94-98% | 93-97% | 95-99% | 50-90% | 80-95% | 80-95% |
| **Features** | Most common & cost-effective type of gear | Higher strength and durable than spur gears | Durable & ideal for high load applications | Highly durable & can handle high load than straight bevel | Can be used for special occupations | Durable & ideal for high load applications and transmit high torque | Ideal for light load applications and transmit low torque |
| **Noise and Vibration** | Noisy | Less than spur gears | Less than spur gear | Less than straight Bevel | Quiet and Smooth | Quiet operation than spiral bevel | Quiet operation than spiral bevel |
| **Application** | Conveyors, Constant | Automobile transmission | Printing press, Differential gear | Tractors, final reduction gearing | Anti Reversing, Indexing devices | Large trucks | Roving machine |

# Line of Action

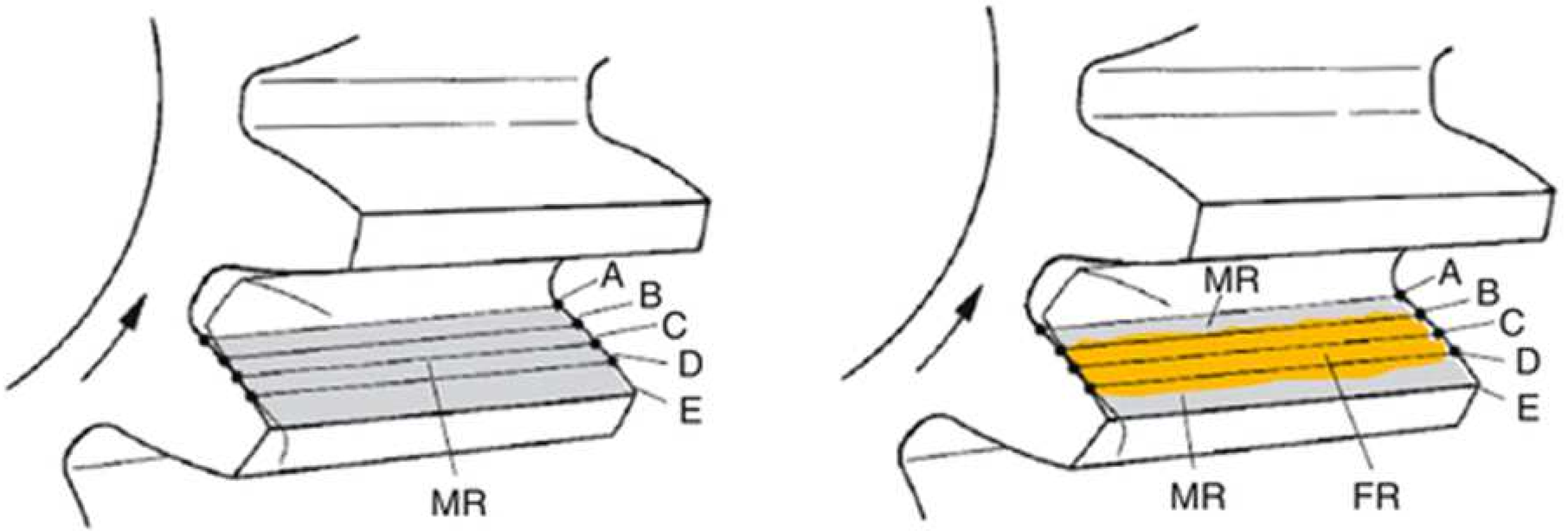
contact points according to DIN 3980



# Sliding friction on gear mesh



# Stages of friction




**a** low peripheral speed

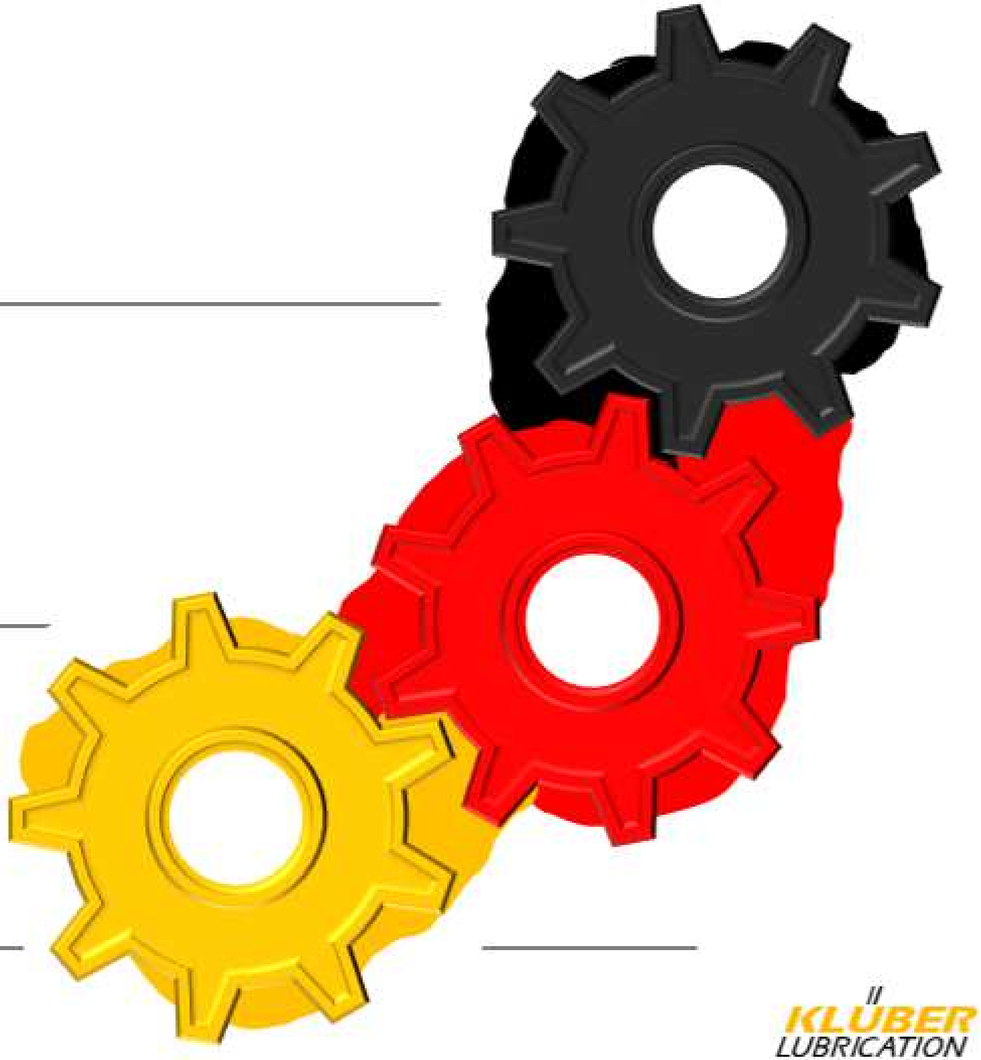
**b** high peripheral speed

# Gear lubrication Method

Grease Lubrication

Splash Lubrication (oil bath method)

Forced oil circulation Lubrication



# Gear lubrication Method

## Grease Lubrication

Suitable for any gear system that is open or enclosed, so long as it run at low speed.

The major points regarding grease lubrication are:

- Choosing a lubricant with suitable cone penetration.
  A lubricant with good fluidity is especially effective in an enclosed system.

- Not suitable for use under high load and continuous operation.
  The cooling effect of grease is not as good as lubricating oil. So it may become a problem with temperature rise under high load and continuous operating conditions.

- Proper quantity of grease.
  There must be sufficient grease to do the job. However, too much grease can be harmful, particularly in an enclosed system. Excess grease will cause agitation, viscous drag and results in loss of power.

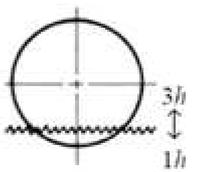
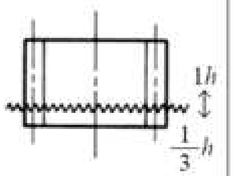
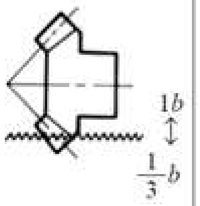
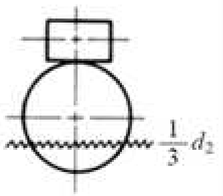
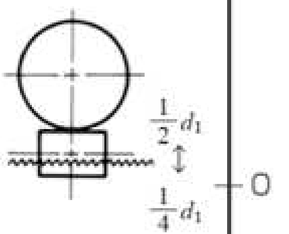
# Gear lubrication Method

## Splash Lubrication (oil bath method)

Splash lubrication is used with an enclosed system. The rotating gears splash lubricant onto the gear system and bearing. It needs **at least 3 m/s** tangential speed to be effective.

The major points regarding use of splash lubrication are:

- Oil level:
  There will be excess agitation loss if the oil level is too high. On the other hand , there will not be effective lubrication or ability to cool the gears if the level is too low.

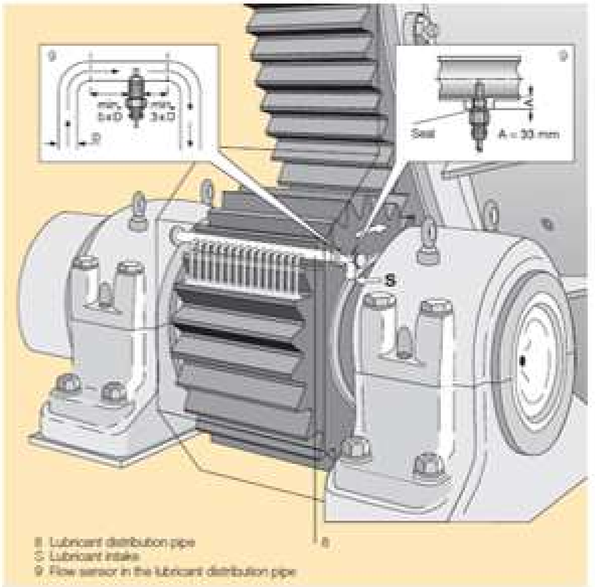
| Type of gears | Spur gears and helical gears | | Bevel gears | Worm gear pair | |
|---|---|---|---|---|---|
| Gear orientation | Horizontal shaft | Vertical shaft | (Horizontal shaft) | Worm - above | Worm -below |
| Oil level<br>Level O |  |  |  |  |  |

$h$ = Tooth depth, $b$ = Facewidth, $d_2$ = Reference diameter of worm wheel, $d_1$ = Reference diameter of worm

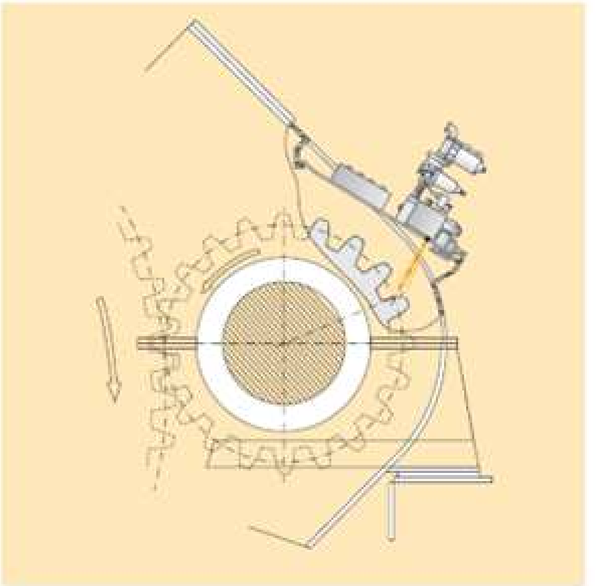
# Gear lubrication Method

## Forced oil circulation Lubrication

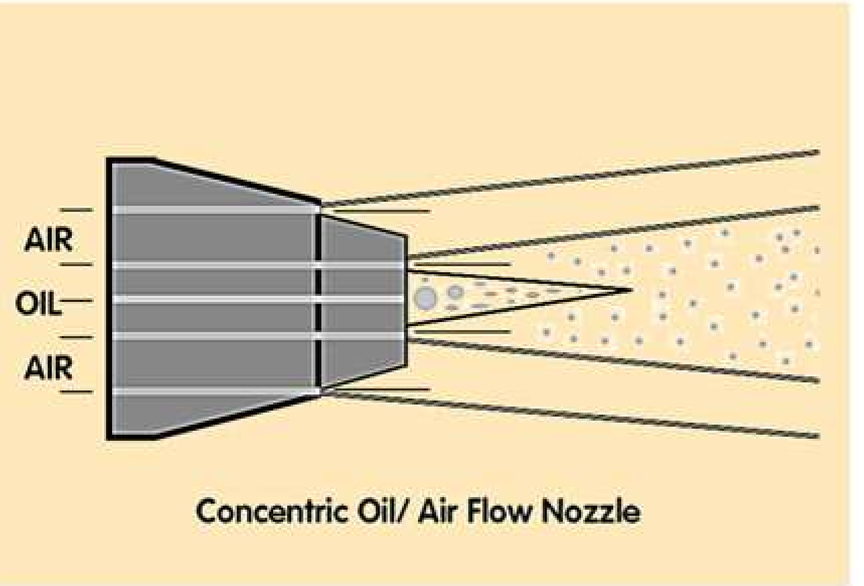
Forced oil circulation lubrication applied lubricant to the contact point of teeth by means of an oil pump. Force-feed lubrication is suitable for even the highest peripheral speeds encountered in gear systems. Oil is brought onto the tooth flanks via slotted or perforated nozzles. The injection quantity depends on the amount of heat to be dissipated.




**Drop Method**



**Spray Method**




**Oil Mist Method**

# Gear lubrication Method

## Compare Three lubrication Methods

There is no single best lubricant and method. Choice depends upon tangential speed (m/s) and rotating speed (rpm)

| No. | Lubrication | Range of tangential speed $v$ (m/s) For spur and bevel gears | Range of tangential speed $v$ (m/s) For worm wheels |
|---|---|---|---|
| 1 | Grease Lubrication | 0 5 10 15 20 25 | 0 5 10 15 20 25 |
| 2 | Splash Lubrication | | |
| 3 | Forced oil circulation Lubrication | | |

# Properties of gear oils

Gear oil properties are determined by the **base oil** and the **additives**. The essential requirements on gear oils are described by leading gear manufacturers in international standards and specifications. They include:

- Operating temperature range
- Viscosity
- Ageing behavior
- Low-temperature behavior
- Corrosion protection on steel / nonferrous metal
- Foaming behavior
- Elastomer compatibility
- Compatibility with interior coatings
- Wear protection – fretting, micro pitting.

# Gear oil requirement

DIN 51502

C = Lubricating oils (circulating oil systems).

L = ‘C’ with corrosion-inhibiting additives that increase the resistance to ageing

P = ‘C’ with anti-friction & anti-wear additives for mixed-friction range operation to increase the load carrying capacity

Lubricating oils CLP → Gear oils

Minimum requirement of Lubricating oil CLP

DIN 51517-3

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# Gear oil requirement

Acc. to DIN 51517-3 – Lubricating oils CLP

| Viscosity grade according to DIN ISO 3448 | | | CLP 32 | CLP 46 | CLP 68 | CLP 100 | CLP 150 | CLP 220 | CLP 320 | CLP 460 | CLP 680 | CLP 1000 | CLP 1500 | Unit | Test Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kinematic viscosity | at 40°C | MIN | 28.8 | 41.4 | 61.2 | 90.0 | 135.0 | 198.0 | 288.0 | 414.0 | 612.0 | 900.0 | 1350.0 | mm/s. | DIN EN ISO 3104 |
| | | MAX | 35.2 | 50.6 | 74.8 | 110.0 | 165.0 | 242.0 | 352.0 | 506.0 | 748.0 | 1100.0 | 1650.0 | | |
| Viscosity index | | MIN | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 85 | 85 | 85 | - | DIN ISO 2909 |
| Density | at 15°C | - | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | kg/m3 | DIN 51757 |
| Flash point | | MIN | 180 | 180 | 180 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | °C | DIN EN ISO 2592 |
| Pour point | | MAX | -12 | -12 | -12 | -12 | -9 | -9 | -9 | -9 | -3 | -3 | -3 | °C | DIN ISO 3016 |
| Neutralisation number | | - | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | mg KOH/g | DIN ISO 6618 |
| Water content | | MAX | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | % | DIN 51777-2 |
| Demulsibility | at 54°C | MAX | 30 | 30 | 30 | - | - | - | - | - | - | - | - | min. | DIN ISO 6614 |
| | at 82°C | MAX | - | - | - | 30 | 30 | 30 | 30 | 45 | 60 | 60 | 60 | min. | |
| Copper corrosion | increase viscosity at 100°C | MAX | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Rating | DIN EN ISO 2160 |
| Steel corrosion | increase viscosity at 100°C | - | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | - | DIN ISO 7120 |
| Resistance to aging | increase viscosity at 100°C | MAX | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | % | DIN EN ISO 4263-4 |
| | increase in soluble content | MAX | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | mL. | |
| Foam charateristic | immediately | MAX | 100 | 100 | 100 | - | - | - | - | - | - | - | - | mL. | ISO 6247 |
| | after 10min. | MAX | 10 | 10 | 10 | - | - | - | - | - | - | - | - | mL. | |
| Flender foam test | after 1min. | MAX | - | - | - | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | % | ISO 12152 |
| | after 5min. | MAX | - | - | - | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | % | |
| FAG FE8 wear test | wear of rolling element | MAX | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | mg. | DIN 51819-3 |
| | wear of cage | - | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | mg. | |
| FZG scuffing load test | | MIN | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | Load stage | DIN ISO 14635-1 |
| Elastomer compatibility | | - | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | Reported | % | DIN ISO 1817 |

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# Lubricant testing
## Chemico-physical characteristics

Chemico-physical characteristics (Acc. to DIN 51517-3)

Kinematic viscosity

Neutralization number

Demulsibility

Density

Copper corrosion

Aging behavior

Foam characteristics

Steel corrosion

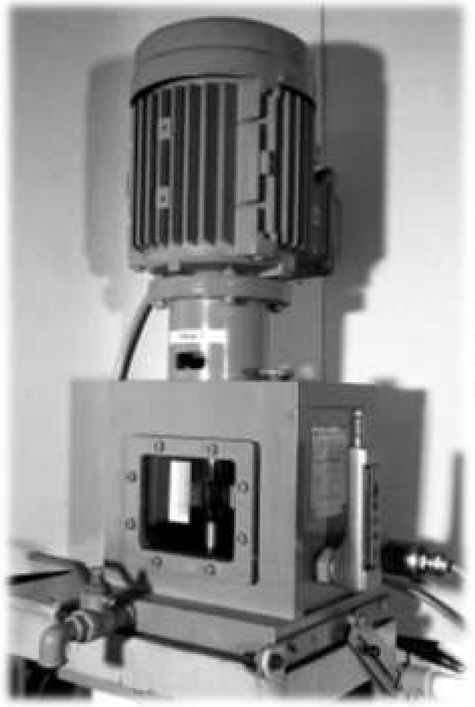
Water content

Pour point

Flash point

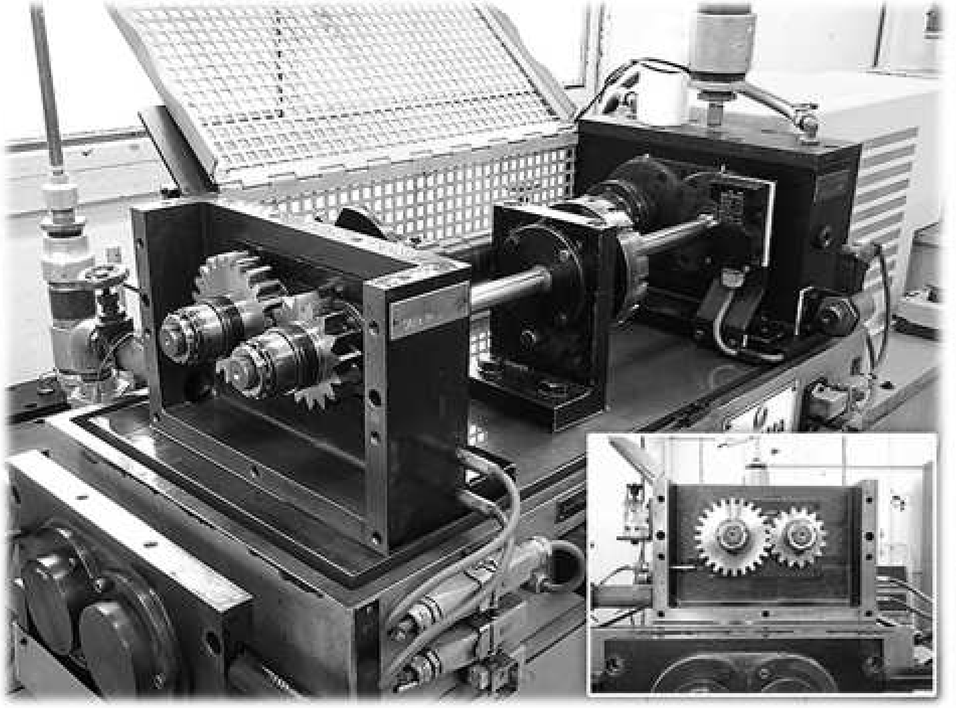
# Lubricant testing
## Mechanico-dynamical tests

Mechanico-dynamical tests (Acc. to DIN 51517-3)



Flender foam test


FAG FE8 wear test



FZG Scuffing load test

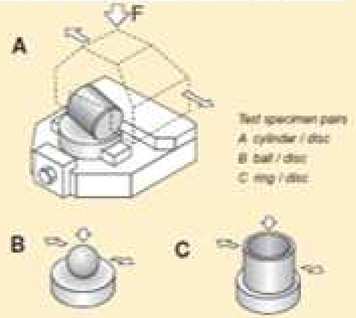
Elastomer compatibility

# Lubricant testing

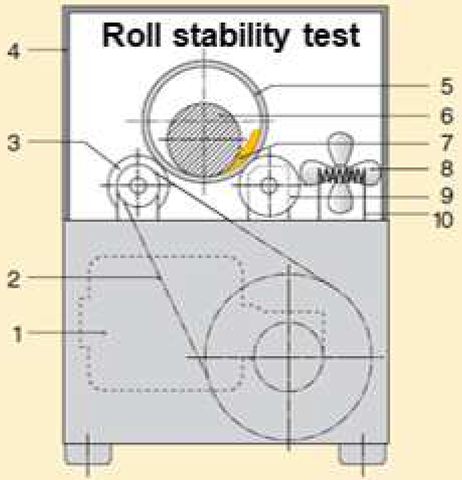
## Mechanico-dynamical tests

Mechanico-dynamical tests (related gear oil testing)

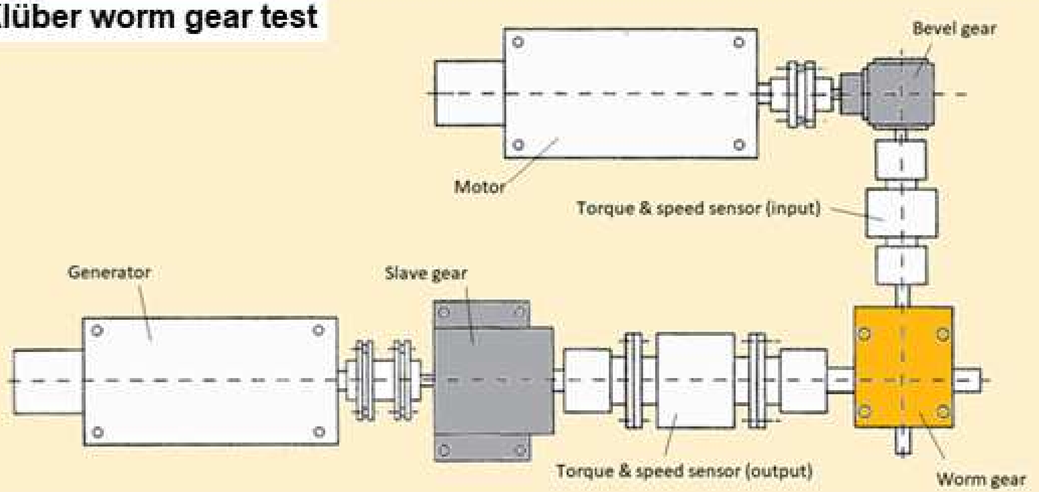
### Oscillation sliding test



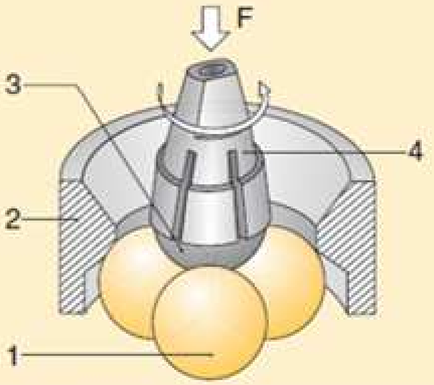

### Roll stability test



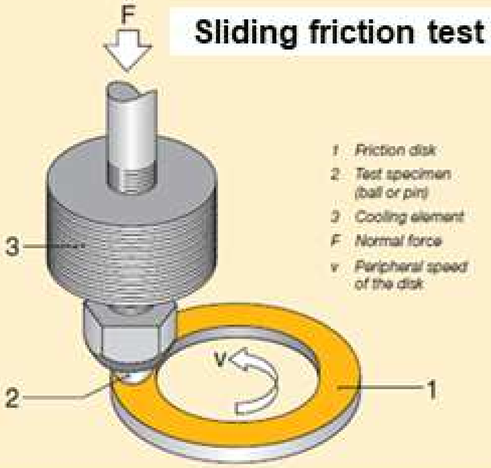

### Klüber worm gear test



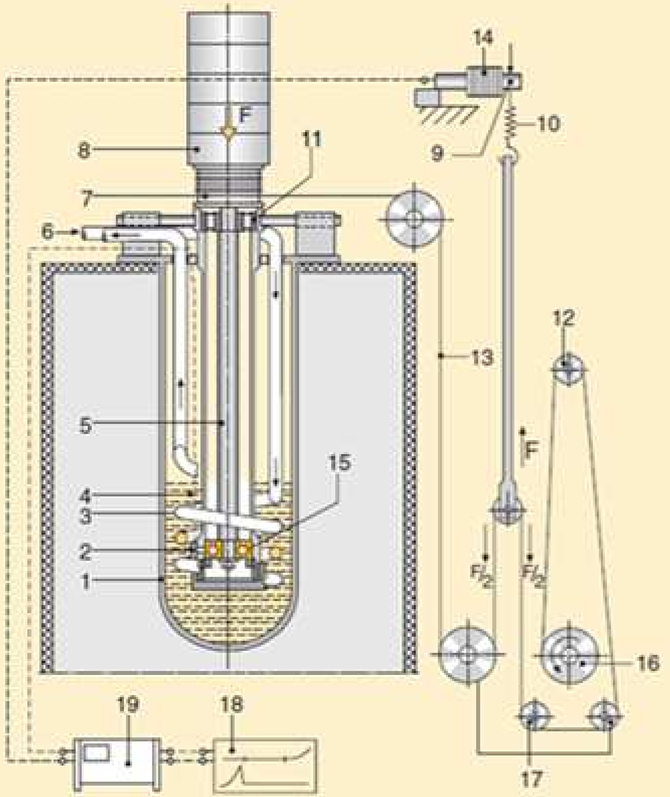

### VKA Four ball test




### Sliding friction test




### Low temperature torque test



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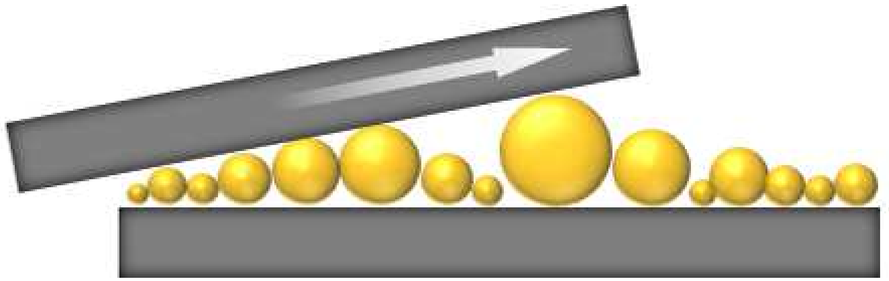
# Product Information

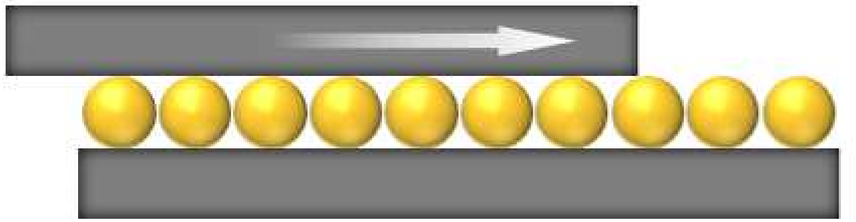
# Benefits of synthetic gear oils

## Molecular uniform sized

**Mineral gear oil**



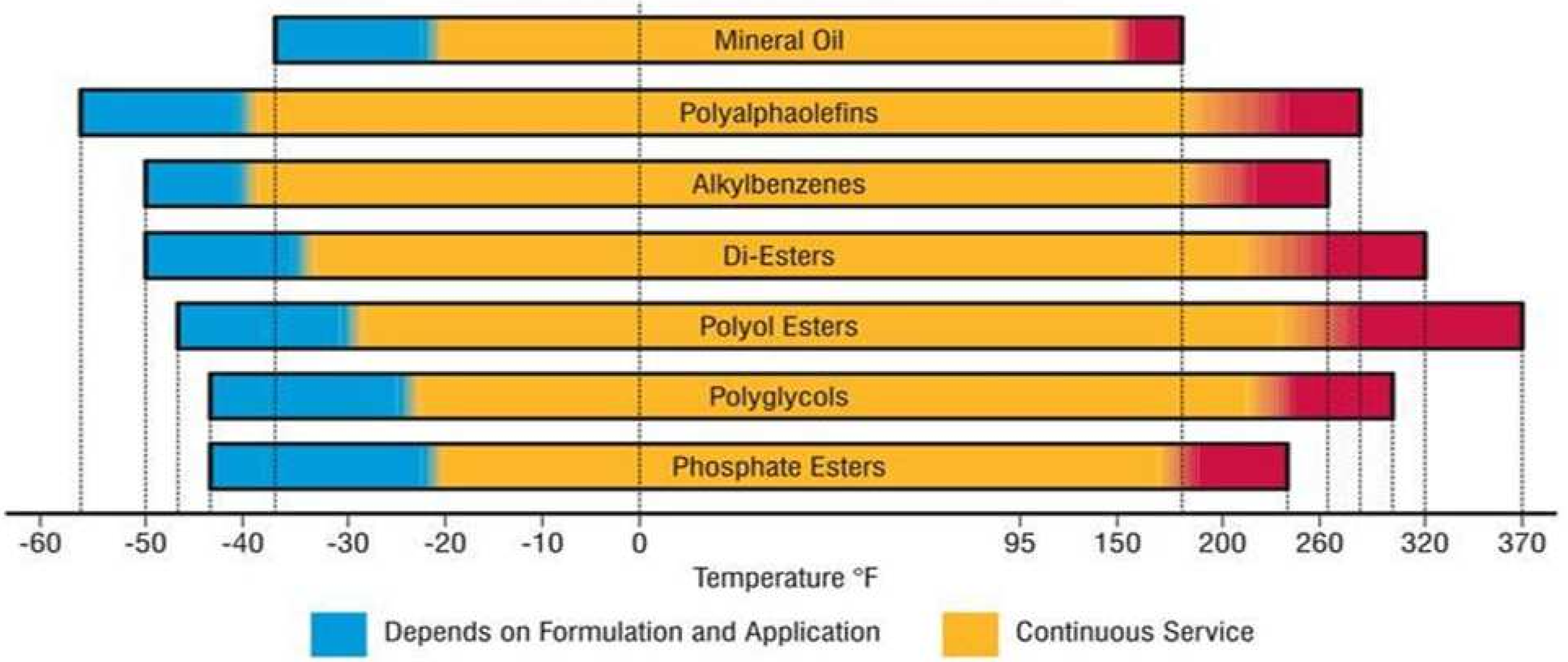
**Synthetic gear oil**



Because synthetic oil is man-made in a laboratory, the molecules produced are uniformly sized. This uniformity allows them to maintain their size and viscosity much longer. That's the main reason synthetic oil doesn't need to be changed as often.

# Benefits of synthetic gear oils

## Wide range of service temperature



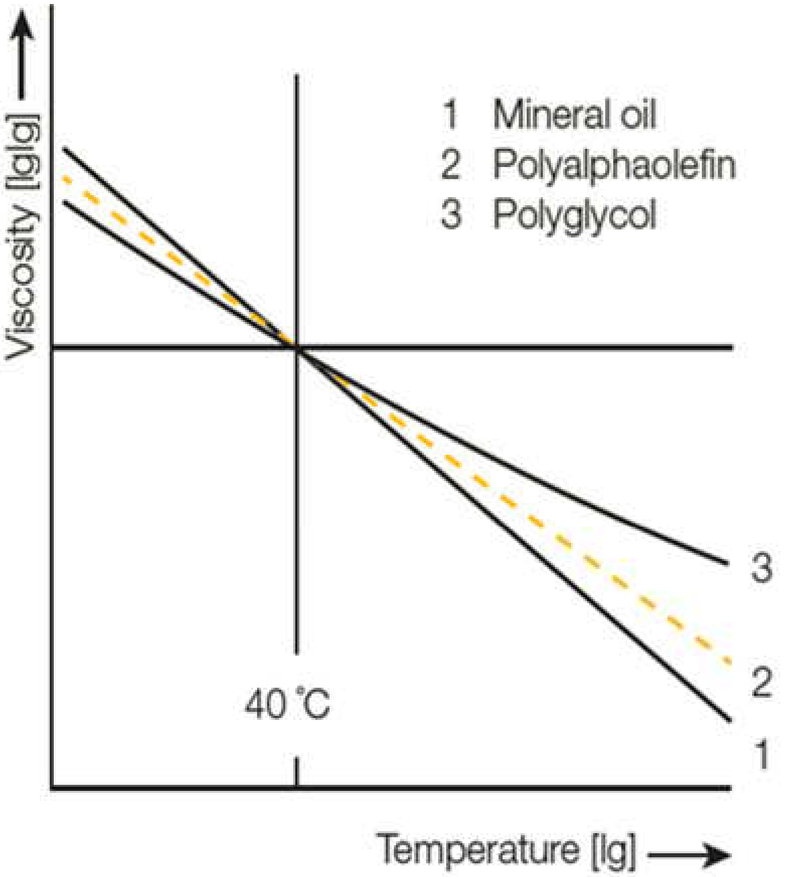
# Benefits of synthetic gear oils

## Better cold start with the same nominal viscosity (ISO VG)

Viscosity is highly influenced by temperature. The change in viscosity with temperature is usually determined by means of the viscosity index (VI). The higher the viscosity index of a gear oil, the less viscosity changes with temperature.

The degree to which viscosity changes with temperature depends on the base oil type, such as Mineral oil, Polyalphaolefin, Ester, Polyglycol, as well as on the VI improver additives contained in the lubricant.

**Hint:** A high viscosity index facilitates start-up at low outside temperatures, reduces power loss to a minimum and enables the formation of a load-carrying lubricant film also at high temperatures.



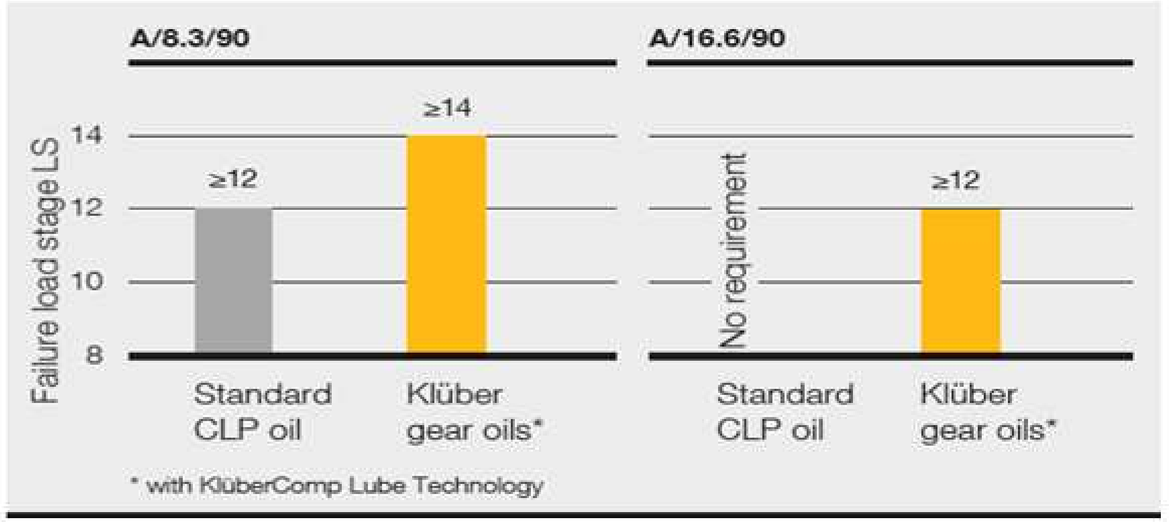
# Benefits of synthetic gear oils

## Higher wear protection

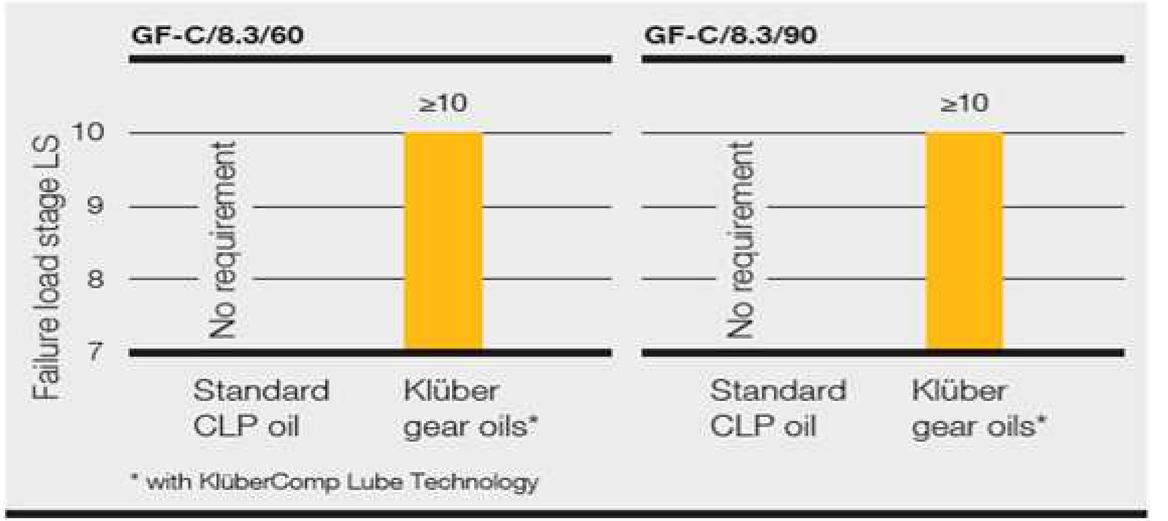
**Scuffing:** According to ISO 14635-1 load stage 12 of FZG scuffing test is the minimum requirement for CLP oils. Klüber Lubrication's gear oils offering superior protection with significantly higher scuffing load stages and speeds even under extreme shock load conditions

**Micropitting:** According to FVA 54/7 has become the industry standard for assessing a gear oil's micropitting load-carrying capacity as low, medium or high. Klüber Lubrication's gear oils are classified as having high micropitting resistance, i.e. load stage ≥ 10.

### FZG scuffing test (results)




### FZG micropitting test (results)



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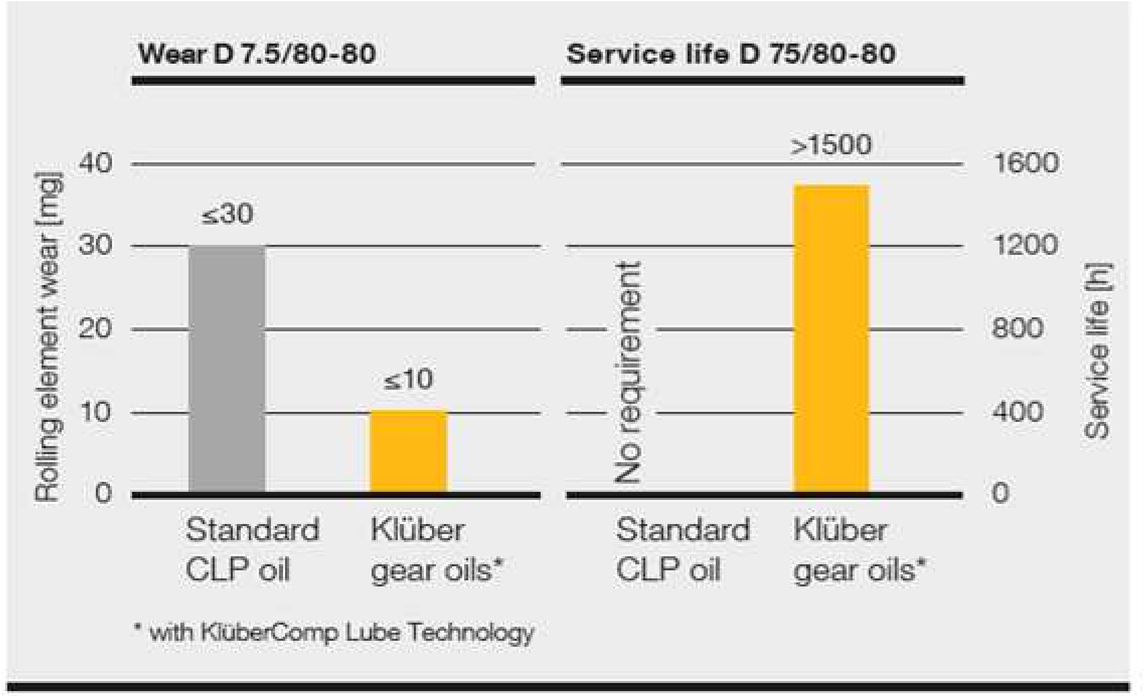
# Benefits of synthetic gear oils

## Higher wear protection

**Protection of rolling bearings:** Apart from the gear teeth, also the rolling bearings have to be protected against high wear and premature fatigue, which are often the reason for gearbox failures. The influence of high-performance gear oils on the wear behaviour of rolling bearings is examined in the FAG FE8 wear test according to DIN 51819-3. Klüber Lubrication's gear oils surpass this test's minimum requirements for CLP oils, while also attaining twice the calculated bearing life in the FE8 lifetime test. Consequently, these rolling bearings can attain the service life projected by the bearing design engineer.

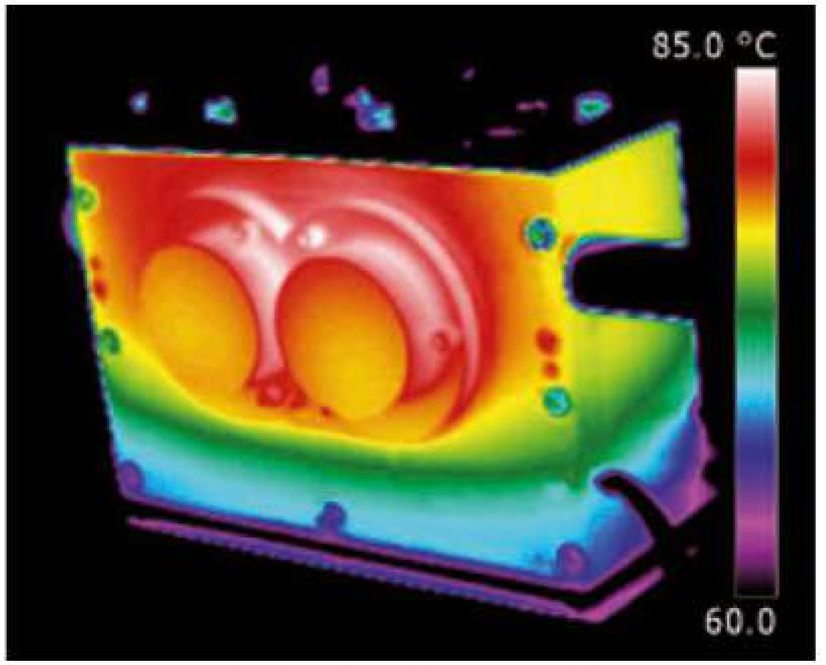
**FE8 rolling bearing test (results)**



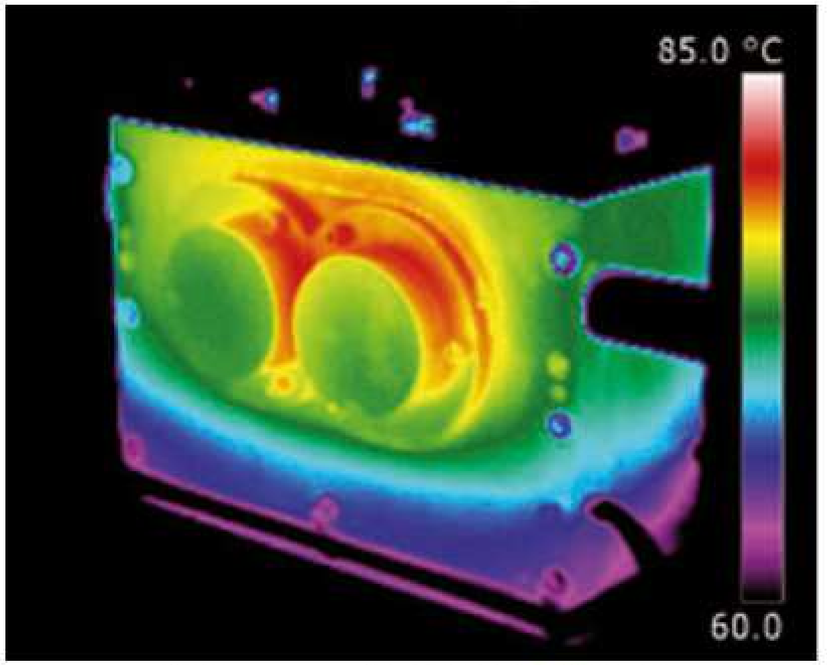
# Benefits of synthetic gear oils

## Lower operating temperature

The synthetic gear oils made by Klüber Lubrication offer significantly higher efficiency than a standard gear oil based on mineral oil, resulting in a lower oil temperature as shown in the thermal pictures.




**Standard gear oil**
(Mineral oil, ISO VG 220)

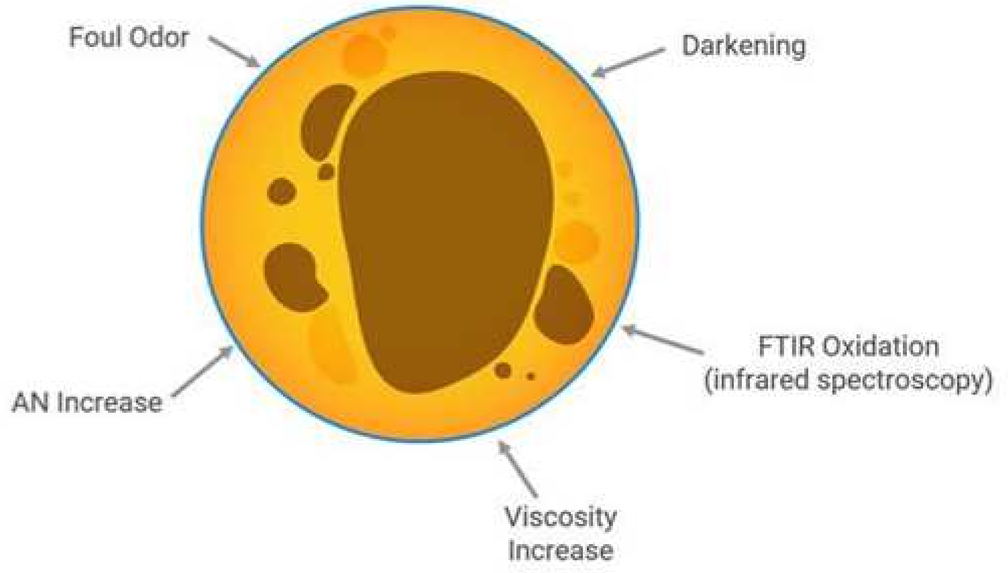



**Klübersynth GEM 4-220N**
(Polyalphaolefin, ISO VG 220)

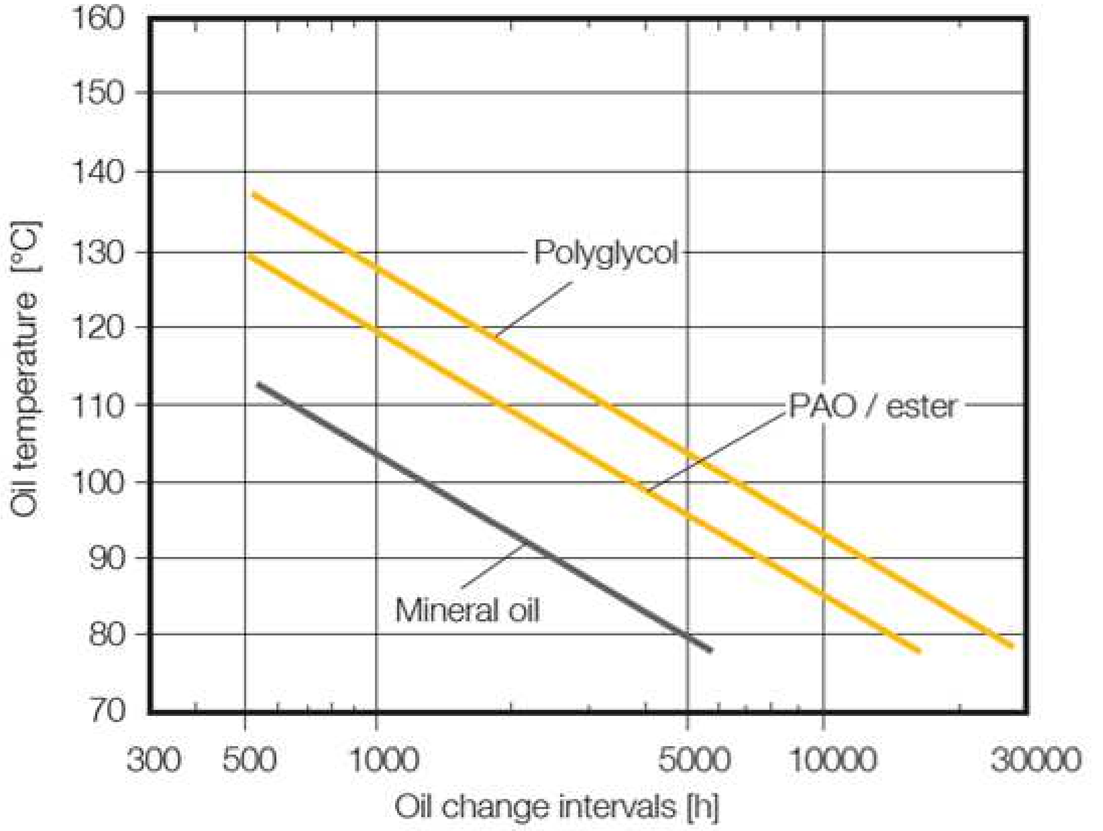
# Benefits of synthetic gear oils

## Longer oil change interval

The prolonged service life of synthetic lubricants and the consequent longer oil change intervals can reduce equipment downtime and save resources. In some cases, lubrication for-life is possible




**Typical oil change intervals**

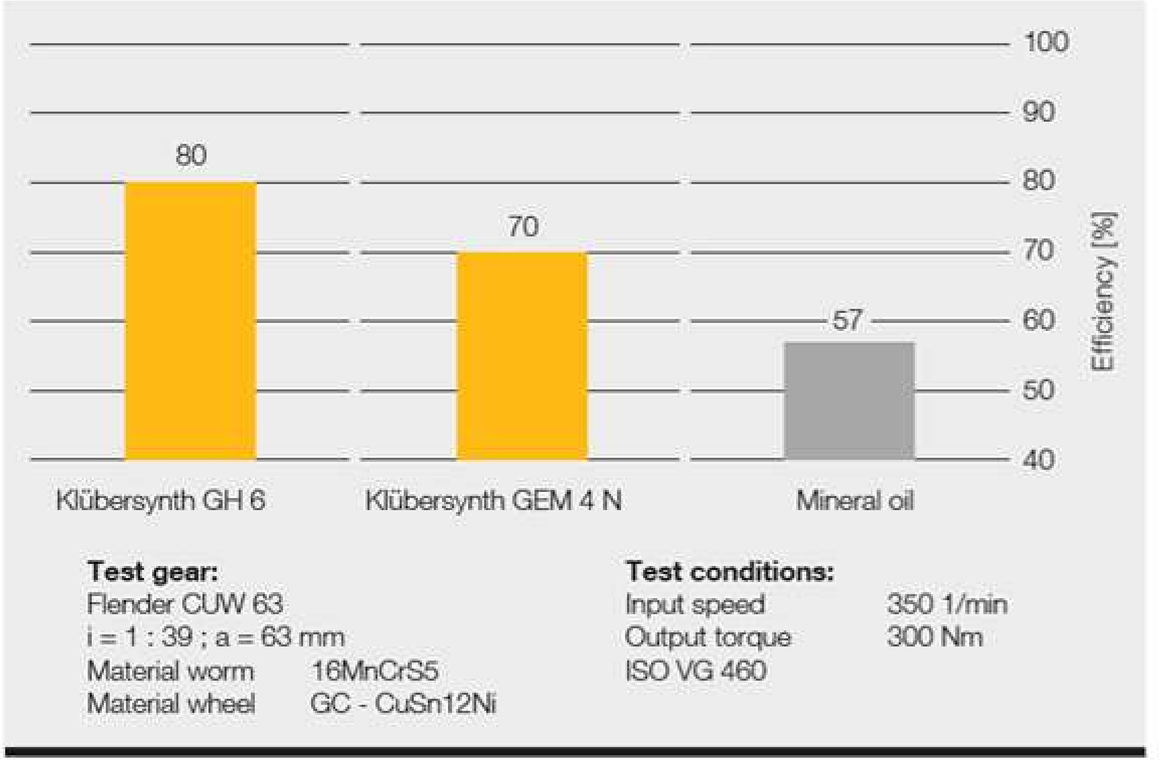


# Benefits of synthetic gear oils

## Improved efficiency

Synthetic gear oils based on polyalphaolefin or polyglycol show a considerably lower gear friction coefficient than mineral oils due to their particular molecular structure. The friction generated in gears with synthetic oils can be more than 30 % lower than that of an industrial EP mineral gear oil. Due to the lower friction coefficients of synthetic gear oils, they help reduce gearing losses considerably and hence increasing gear efficiency.
Especially in gearboxes with a high share of sliding friction, e.g. worm or hypoid gears, a changeover from mineral to synthetic gear oils can lead to increases in efficiency of more than 20 %.

**Efficiency determined on the Klüber worm gear test rig**




**Test gear:**
Flender CUW 63
i = 1 : 39 ; a = 63 mm
Material worm 16MnCrS5
Material wheel GC - CuSn12Ni

**Test conditions:**
Input speed 350 1/min
Output torque 300 Nm
ISO VG 460



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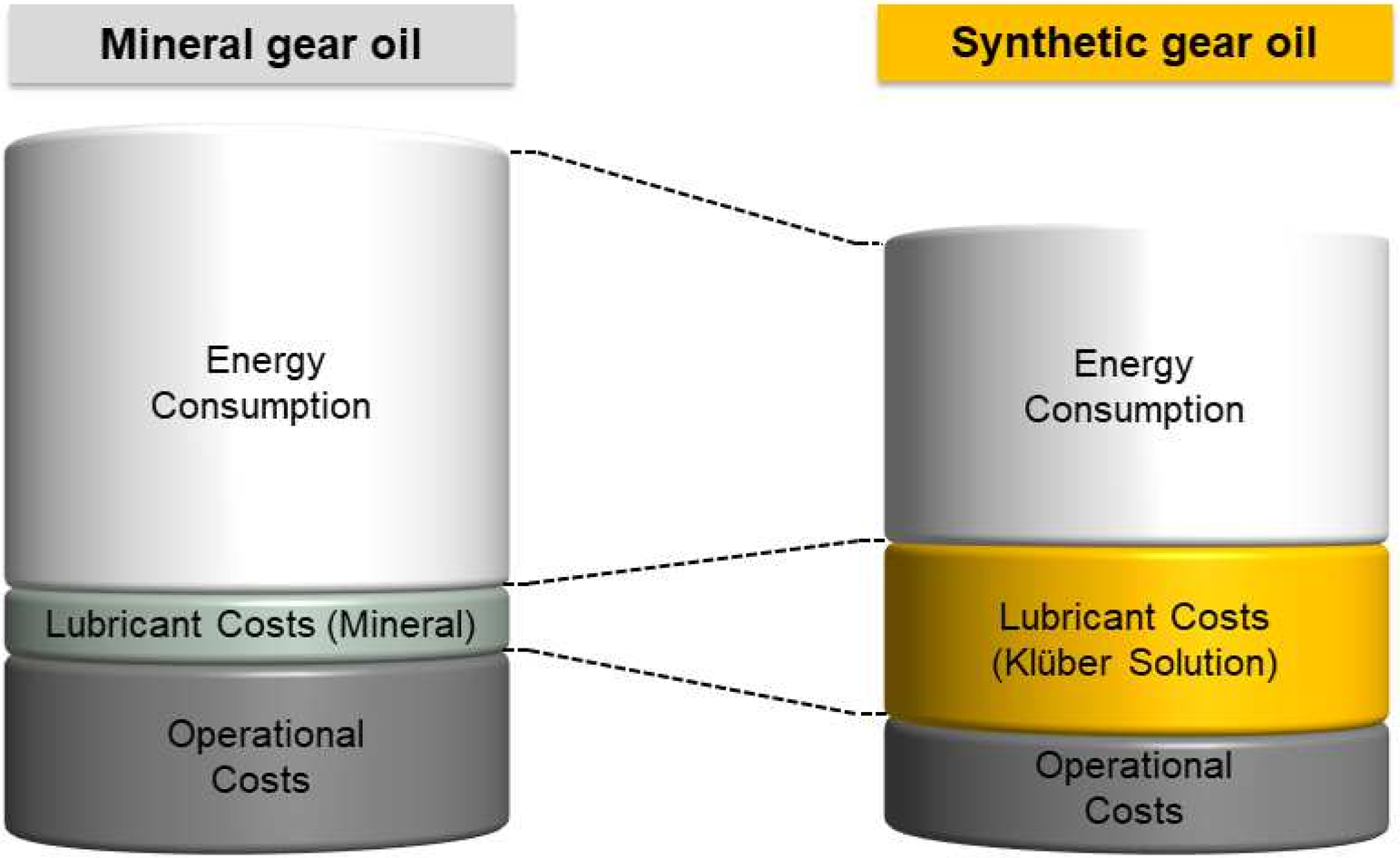
# Benefits of synthetic gear oils

## Improved efficiency

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# Compatibility

## Seals

| | Mineral oil | Polyalphaolefin | Ester oil | Polyglycol | Silicon oil | PFPE |
|---|---|---|---|---|---|---|
| NBR | 👍 | 👍 * | 👎 | 👎 | 👍 | 👍 |
| HNBR/NEM | 👍 | 👍 | 👎 | 👎 | 👍 | 👍 |
| FPM/FKM | 👍 | 👍 | 👍 | 👍 | 👍 | 👍 |
| EPDM | 👎 | 👎 | 👎 | 👍 | 👍 | 👍 |
| ACM | 👍 | 👍 | 👍 | 👍 | 👍 | 👍 |
| AU | 👍 | 👎 | 👎 | 👎 | 👍 | 👍 |

*** Mostly shrink**

# Compatibility

## Plastics

| | Mineral oil | Polyalphaolefin | Ester oil | Polyglycol | Silicon oil | PFPE |
|---|---|---|---|---|---|---|
| POM | 👍 | 👍 | 👍 | 👍 | 👍 | 👍 |
| PA | 👍 | 👍 | 👍 | 👍 | 👍 | 👍 |
| PE | 👎 | 👎 | 👎 | 👍 | 👍 | 👍 |
| PC | 👍 ** | 👍 | 👎 | 👎 | 👍 | 👍 |
| ABS | 👍 | 👍 ** | 👎 | 👎 | 👍 | 👍 |
| PTFE | 👍 | 👍 | 👍 | 👍 | 👍 | 👍 |

** with white oil *** no additive


Thank you for your attention!