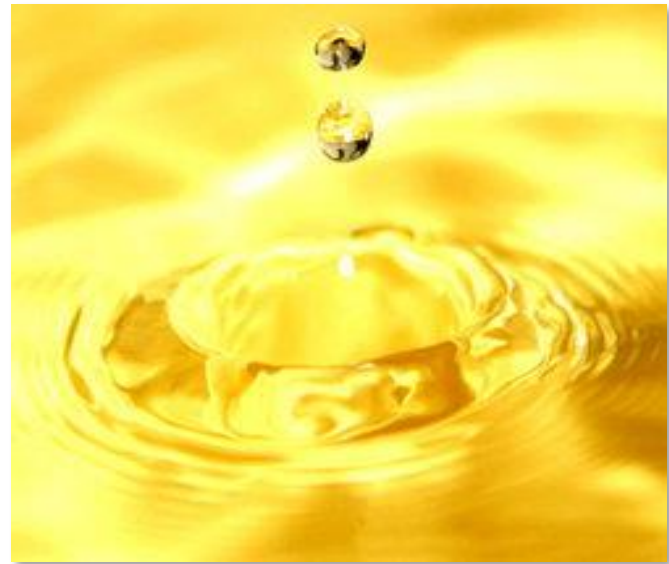




# 潤滑基礎

# 潤滑劑種類

- 潤滑油
- 潤滑脂



# 潤滑油

基礎油  
(80% - 85%)

+

添加劑  
(15% - 20%)

- 石蠟基油
- 環烷基油 (硫基)
- 白油
- 合成油

- (E.P.) 極壓
- 防泡
- 防磨損
- 防鏽
- 防氧化
- 固態潤滑劑
  - 二硫化鋁
  - 石墨
  - 聚四氟乙烯 (特氟龍)

# 潤滑油

## 合成油和礦物油

基礎油種類	礦物	合成烴	有機酯	聚二醇	磷酸酯	矽
黏度指數	F	G	VG	VG	F	E
揮發性	P	G	G	F	FG	G
氧化安定性	F	G	G	F	FG	G
基礎油對添加劑反應	FG	VG	E	G	G	P
防火性	P	P	F	F	VG	F
與礦物油兼容性	E	E	VG	F	G	P
油漆/合成橡膠兼容	FG	G	F	F	P	G

E = 極好    VG = 很好    G = 好    FG = 較好    F = 一般    P = 差

# 固態潤滑劑

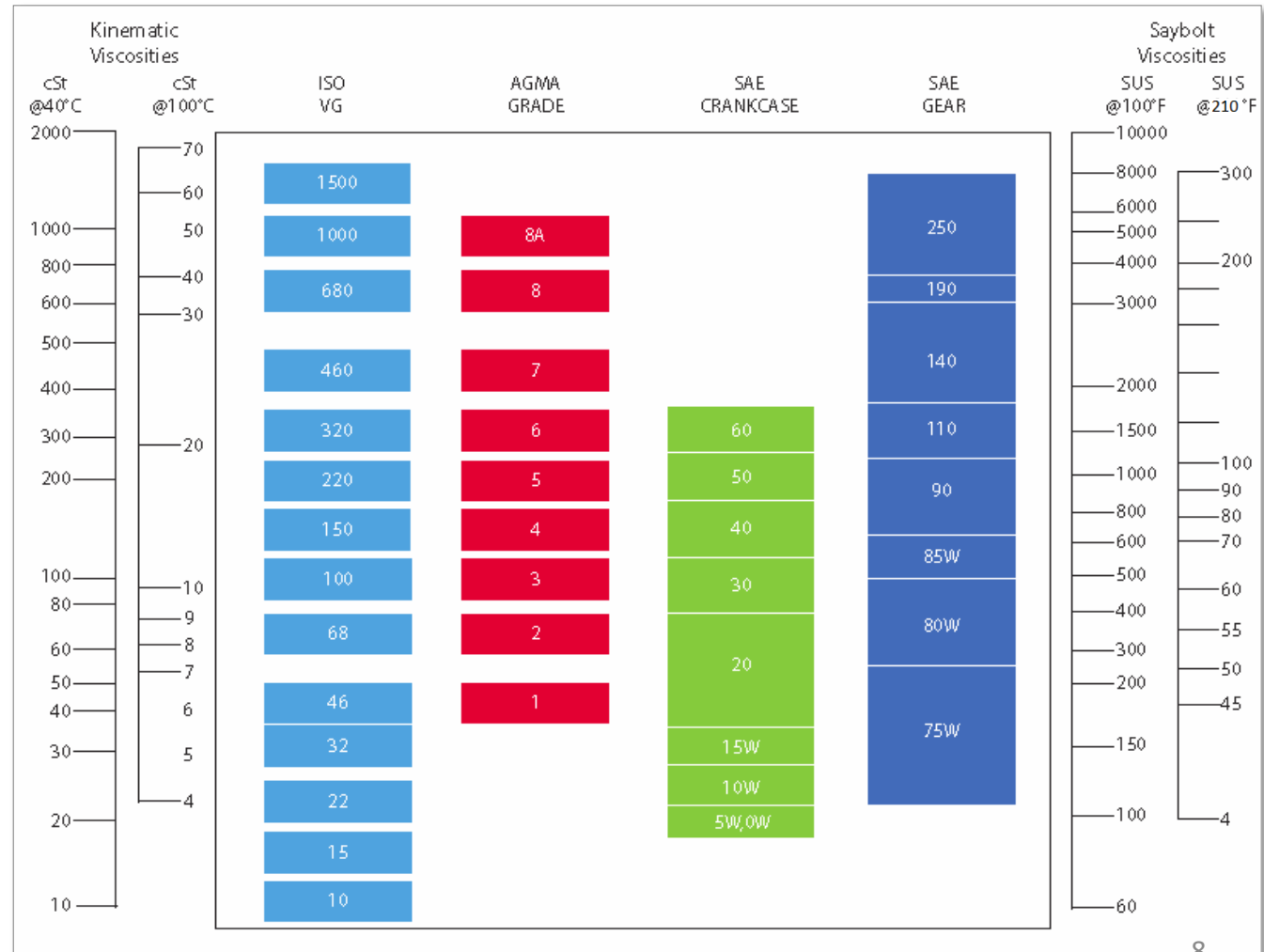
## 常見潤滑顏料的屬性

顏料	二硫化鉬	石墨	(PTFE) 聚四氟乙烯
顏色	灰黑色	灰黑色	白色
負載力(psi)	> 100,000	<50,000	<6,000
熱安定性	好 < 750°F	極好 <1200°F	一般 <500°F
常見微粒大小	2- 6 微米	2.5 – 10 微米	亞微米
真空適用性	可用	不可用	可用
潮濕敏感度	不利	必須	無影響

# 潤滑油的選擇

## 黏度

- 在一定溫度下的流動性



ASTM D 445

# 潤滑油的選擇

- 黏度指數
  - 黏度隨溫度變化的情況
  - 黏度指數為**100**是被認為是極好

ASTM D 2270

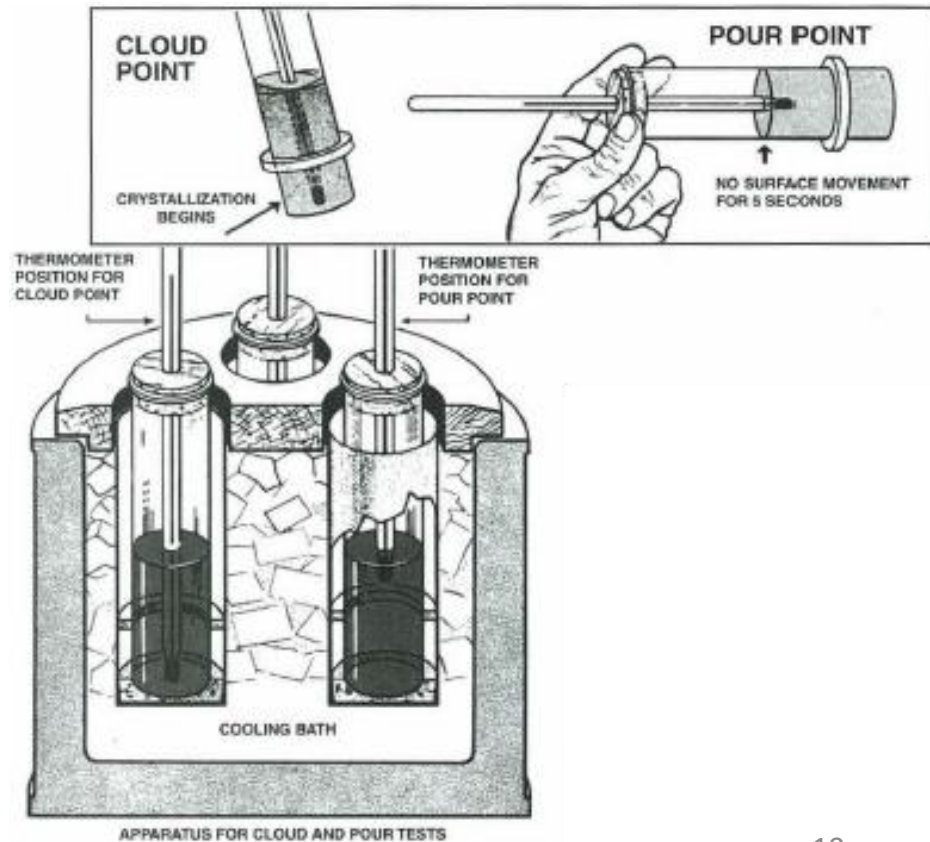


# 潤滑油的選擇

- 傾點
  - 油可以流動或傾倒的最低溫度



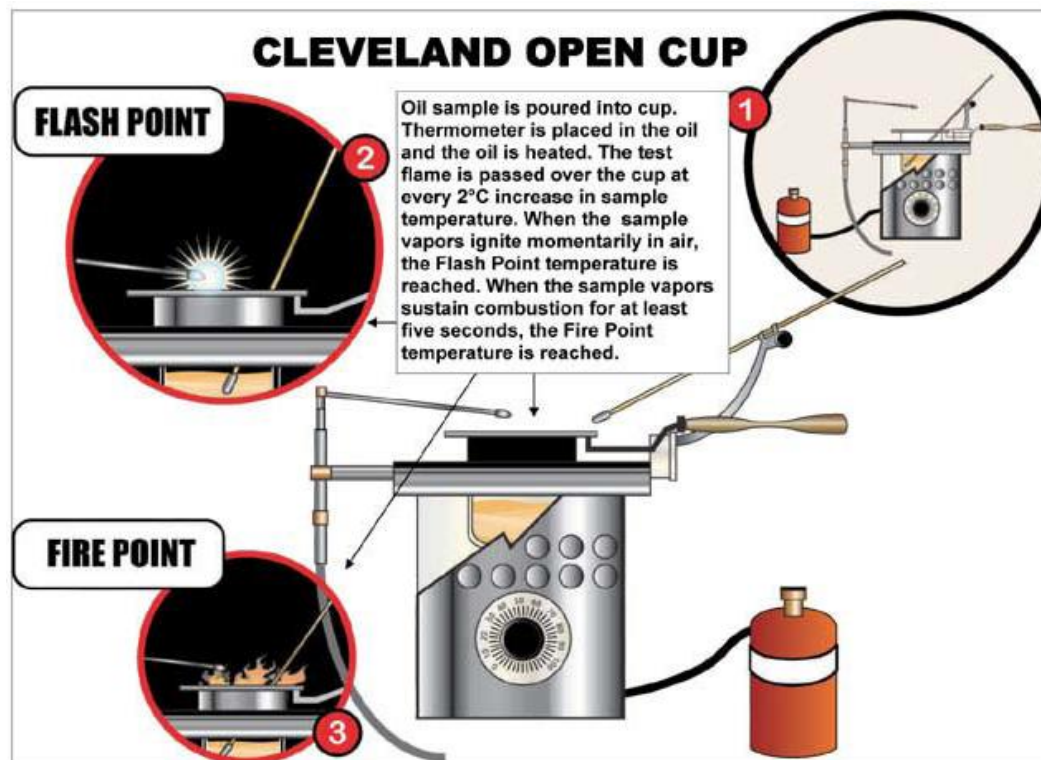
ASTM D 97





# 潤滑油的選擇

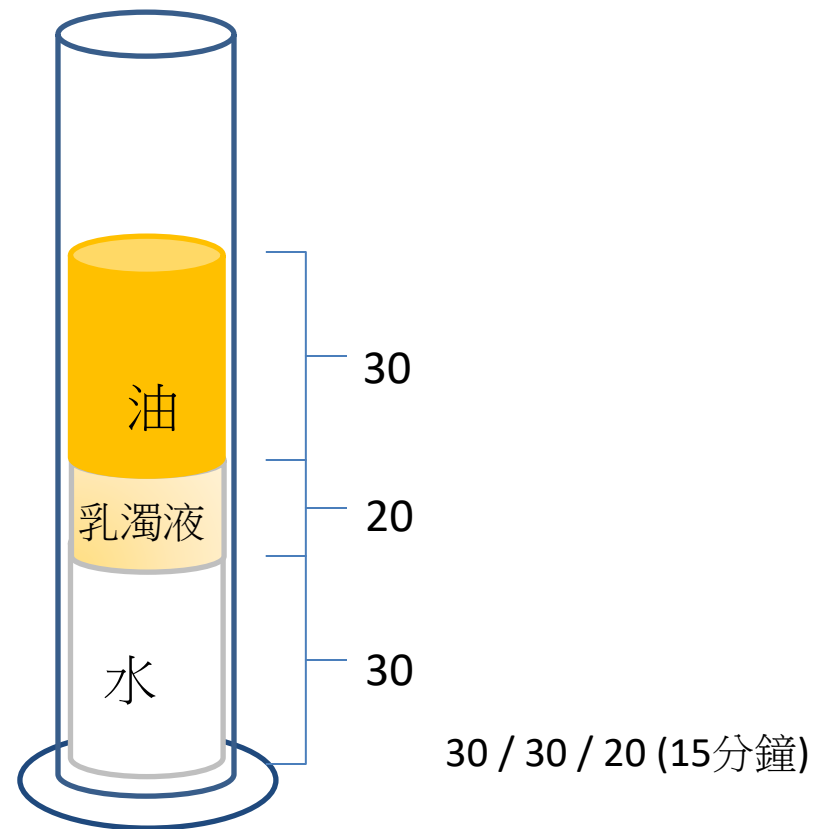
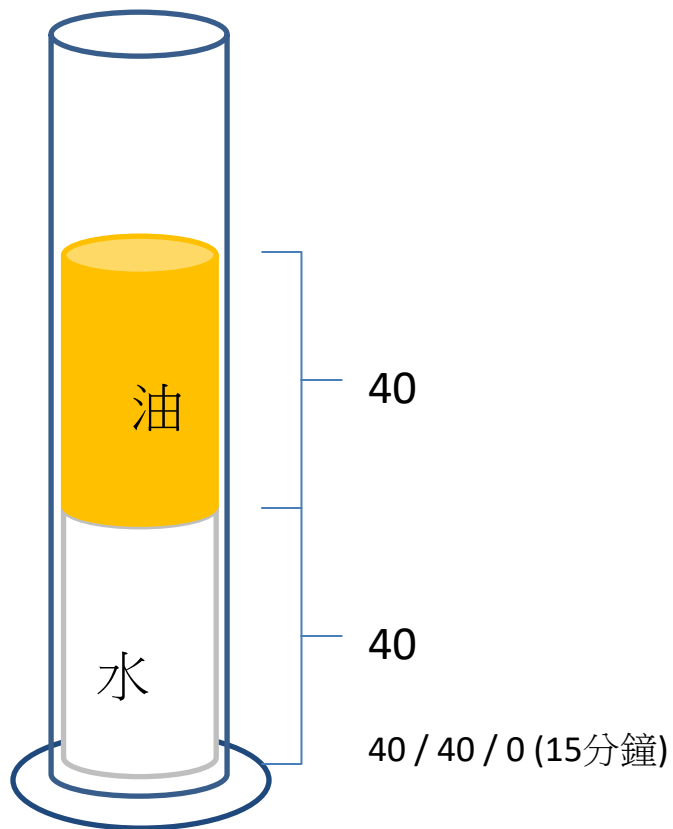
- 閃點和燃點
  - 油蒸發形成可被火焰點燃的氣體的最低溫度



ASTM D 92

# 潤滑油的選擇

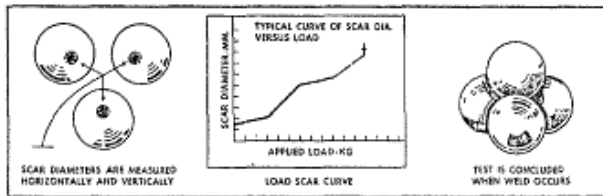
- 抗乳化性



ASTM D 1401

# 潤滑油的選擇

- 四球極壓測試



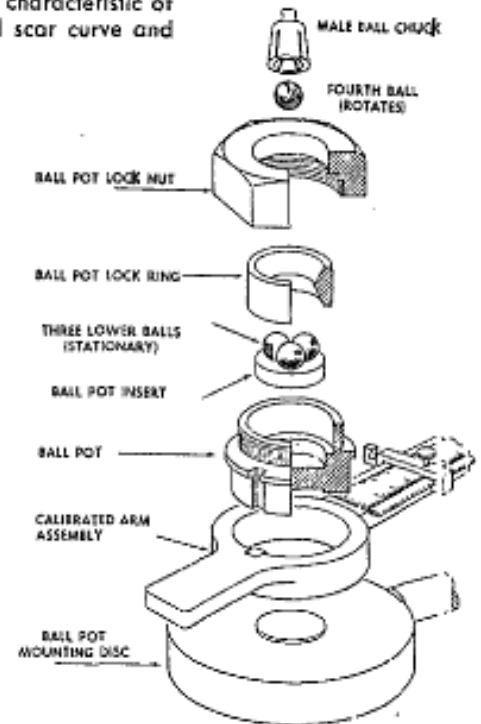
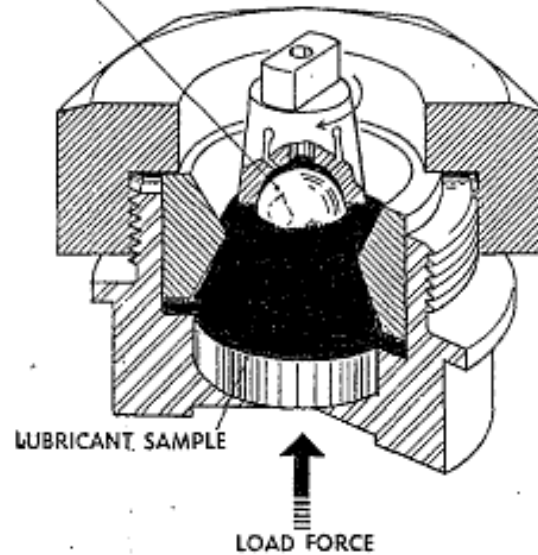
## WHAT IS THE FOUR BALL E.P. TEST?

The determination of the load carrying capacity of a lubricant in kilograms applied to a system of four steel balls in the form of a tetrahedron.

## WHY THE TEST?

To evaluate the E.P. characteristic of lubricants by a load scar curve and weld point.

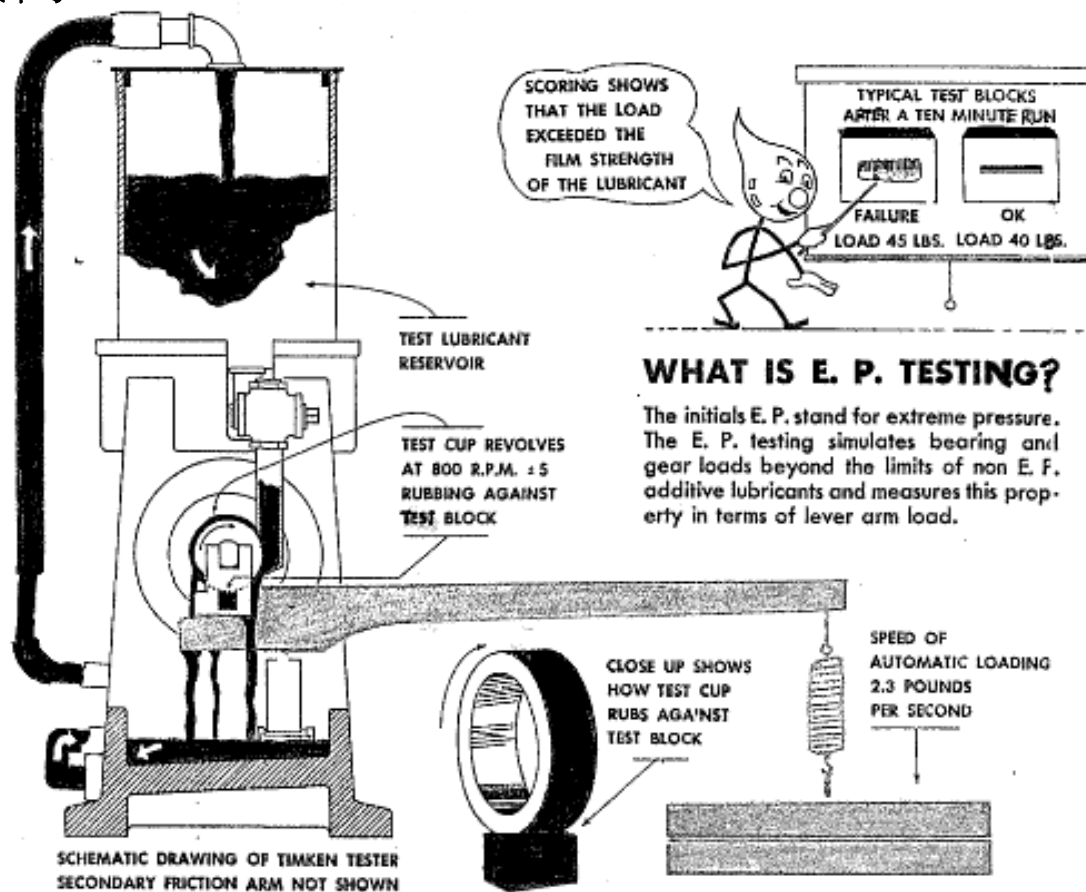
TOP BALL ROTATES AT 1800 R.P.M.



ASTM D 2783 & 4172

# 潤滑油的選擇

- TIMKEN OK負荷
  - 40-50磅.



ASTM D 2782

# 潤滑脂

## 基礎油 (潤滑油)

- 石蠟 (蠟基)
- 環烷 (硫基)
- 白油
- 合成油

+

## 添加劑

- (E.P.) 極壓
- 防磨損
- 防鏽
- 防氧化
- 固態潤滑劑
  - 二硫化鉬
  - 石墨
  - 特氟龍

+

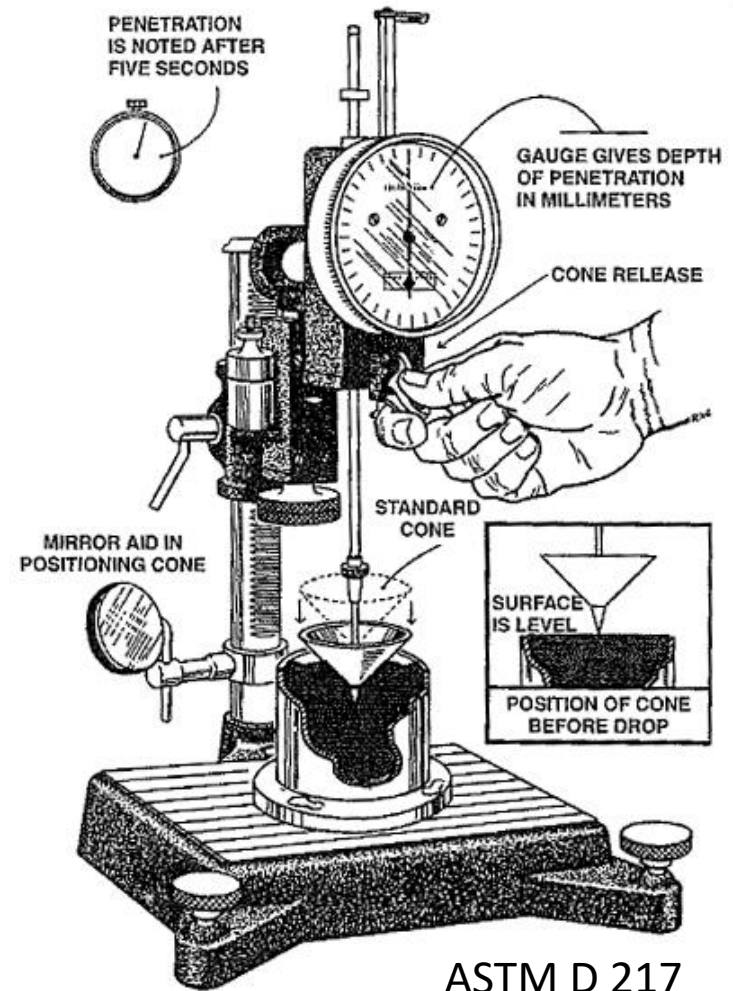
## 增稠劑

- 鈣皂
- 鋁皂
- 鈉皂
- 鋇皂
- 鋰皂
- 複合皂
- 黏土類

# 潤滑脂的選擇

- 錐入度 ( $\text{mm}^{-1}$ )
- NLGI等級

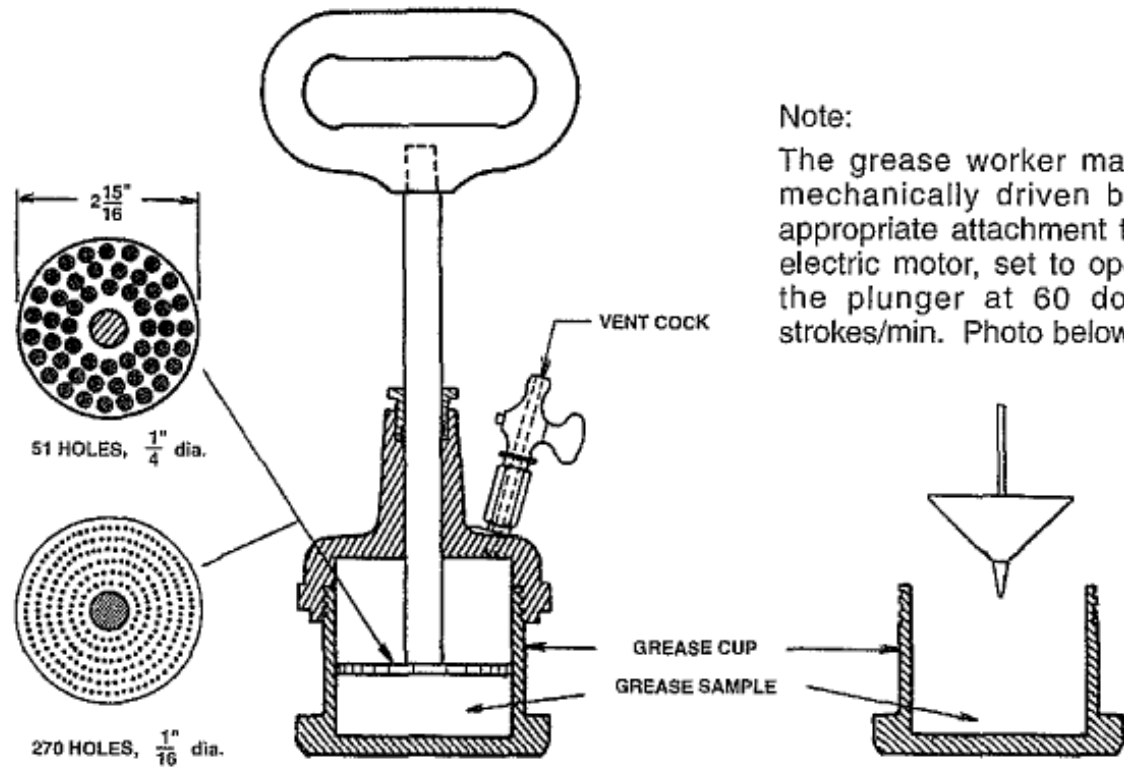
NLGI number	ASTM worked (60 strokes) penetration at 25 °C <i>tenths of a millimetre</i>
000	445-475
00	400-430
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115



# 潤滑脂的選擇

- 脂的抗剪切穩定性

0% ~ 5%	極好
5.1% ~ 15%	好
15.1% ~ 30%	中等
> 30.1%	差

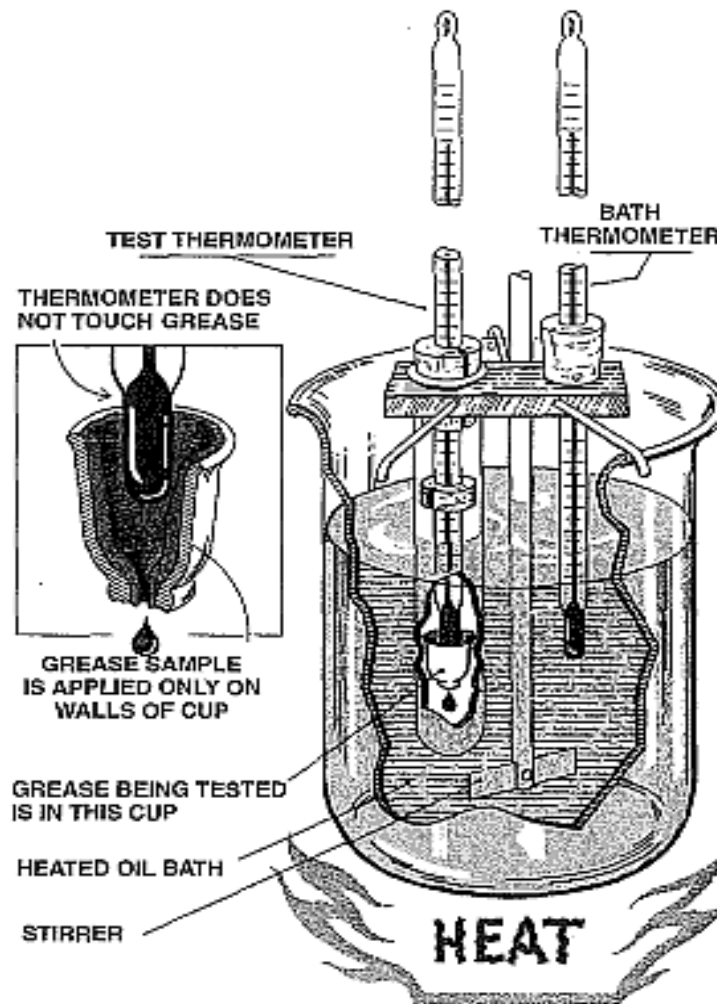


Note:

The grease worker may be mechanically driven by an appropriate attachment to an electric motor, set to operate the plunger at 60 double strokes/min. Photo below.

# 潤滑脂的選擇

- 滴點 (°C)



ASTM D 566 & 2265



# 潤滑脂的選擇

- SKF TMG/Emcor防鏽測試

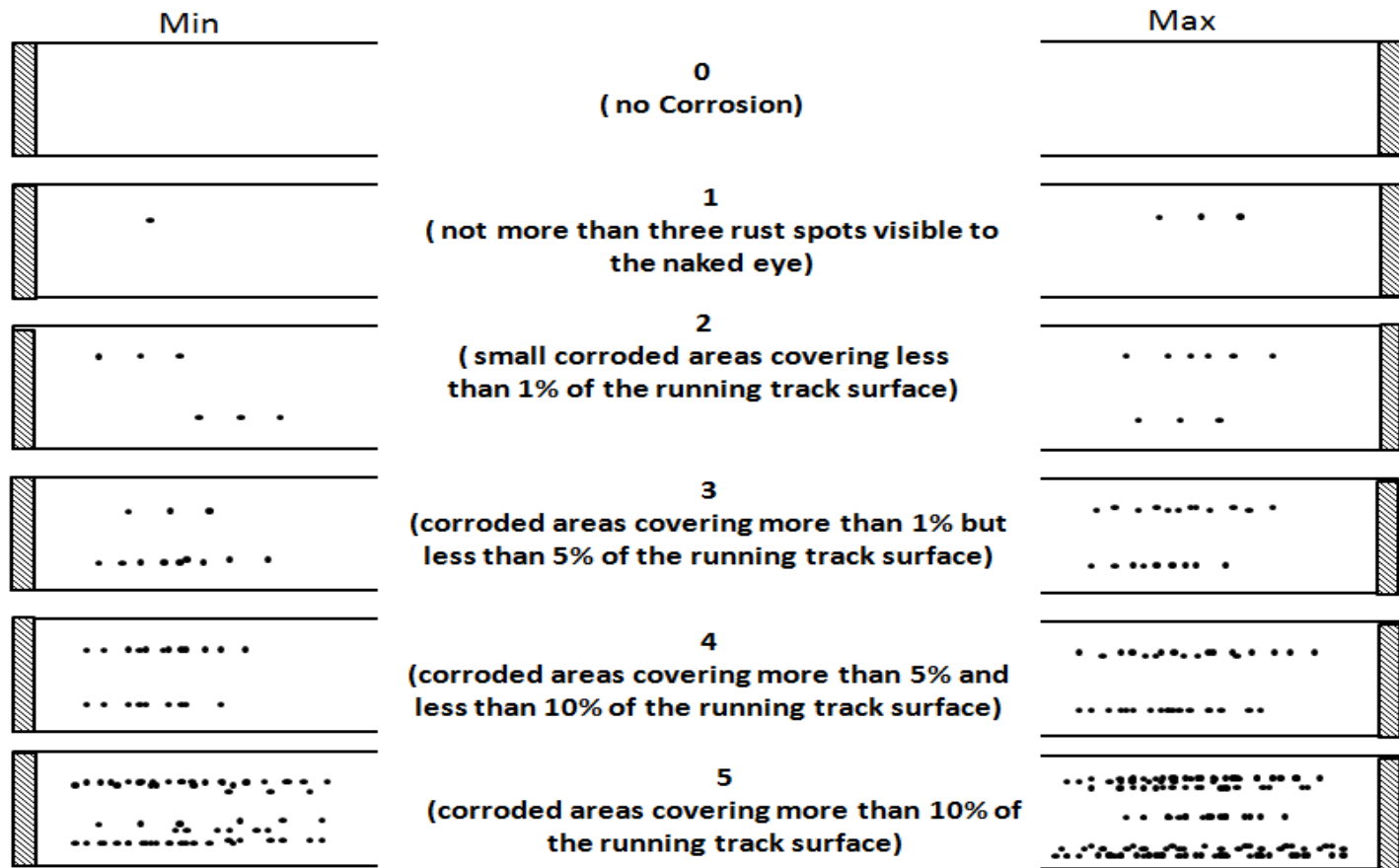


Figure 1- SKF TMG/Emcor Grease Testing Machine Instruction Manual

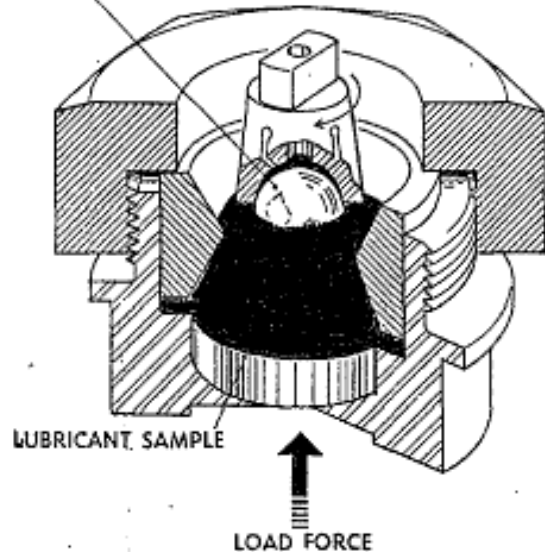
# 潤滑脂的選擇

- 四球極壓測試

## WHAT IS THE FOUR BALL E.P. TEST?

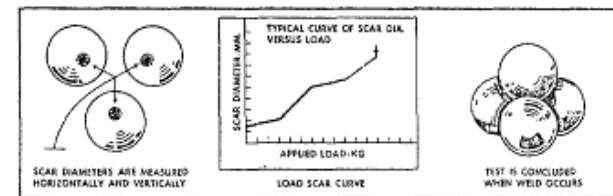
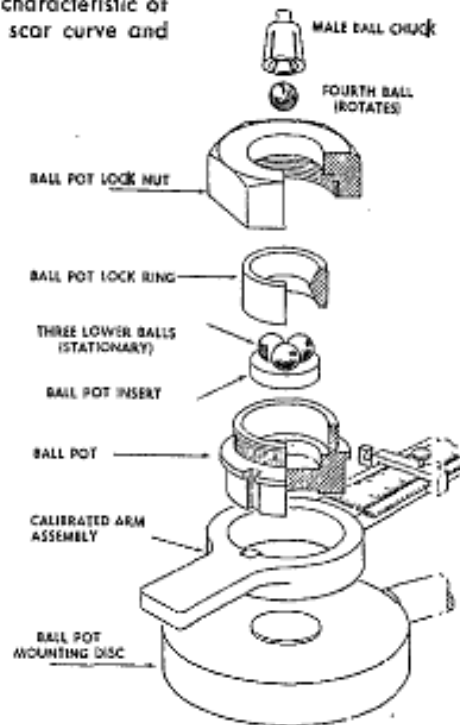
The determination of the load carrying capacity of a lubricant in kilograms applied to a system of four steel balls in the form of a tetrahedron.

TOP BALL ROTATES AT 1800 R.P.M.



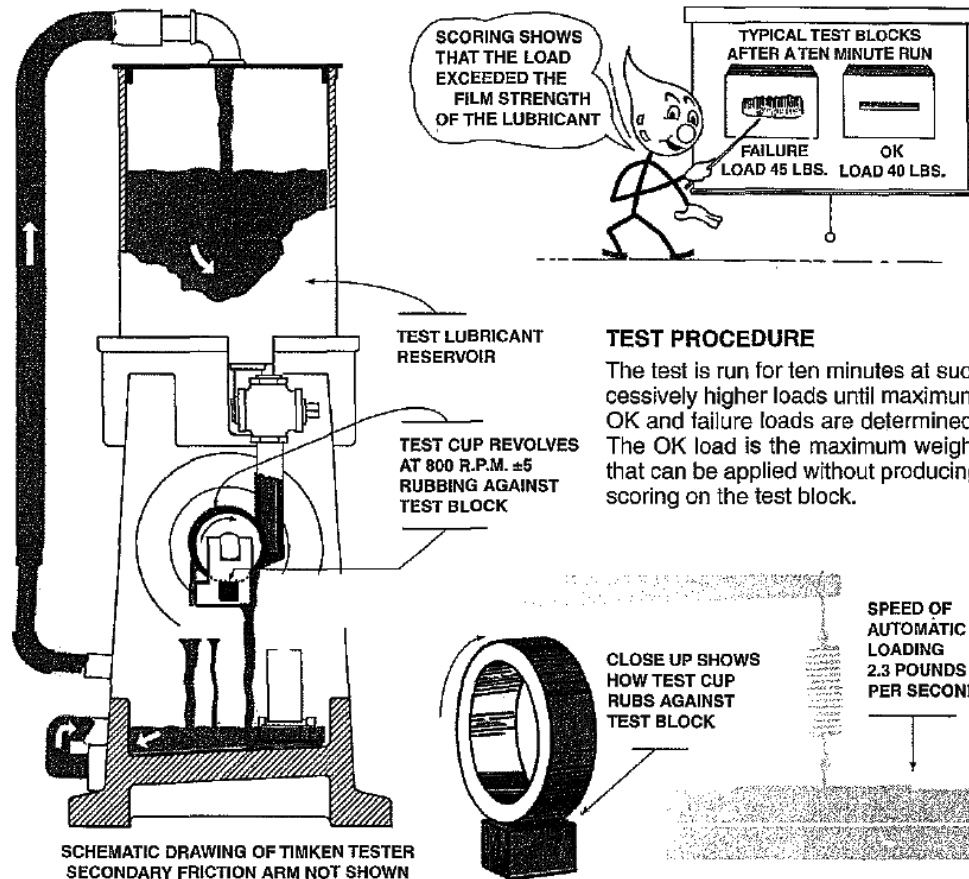
## WHY THE TEST?

To evaluate the E.P. characteristic of lubricants by a load scar curve and weld point.



# 潤滑脂的選擇

- TIMKEN OK負荷（磅）



ASTM D 2509

# 滾動軸承



Deep-groove ball bearing



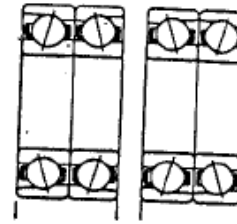
Ball bearing with integral shields



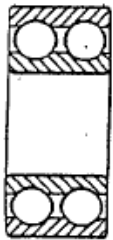
Ball bearing with snap ring



Angular contact ball bearing



Duplex angular contact ball bearings



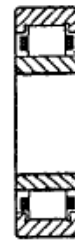
Double-row ball bearing



Self-aligning ball bearing



Ball thrust bearing



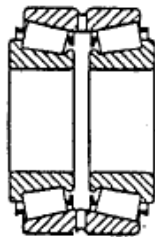
Cylindrical roller bearing



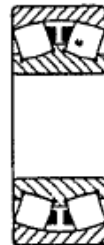
Cylindrical roller bearing with flange on both rings



Tapered roller bearing



Barrel roller self-aligning bearings



Concave roller self-aligning bearing



Needle roller bearing

# 軸承的潤滑解決方案

## 滾動軸承的油潤滑

速度因數 (Bearing bore mm x rpm)	工作溫度範圍			
	0 – 30°C	30 – 60°C	60 – 80°C	80 – 120°C
	<b>ISO</b>	<b>ISO</b>	<b>ISO</b>	<b>ISO</b>
10,000	32 or 68	100	320	1000
25,000	32	100	320	460
50,000	22 – 32	68	220	460
75,000	22	68	220	320
100,000	22	68	150	320
250,000	10	32	100	320
Above 250,000	10	32	100	320

# 軸承的潤滑解決方案

## 滾動軸承的負載範圍

負載	滾珠軸承	滾柱軸承
輕	最高 7% C	最高 8% C
中等	7% C 至 15% C	8% C 至 18% C
重	超過 15% C	超過 18% C

C = 基本負載分級

極低負載 = 1 ~ 2% C

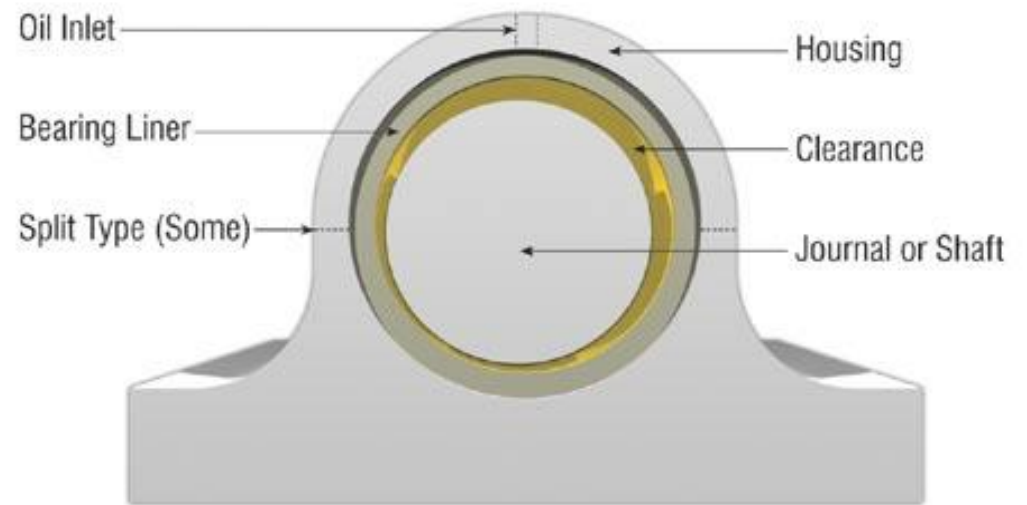
極高負載 = 超過 24 ~ 30% C

# 軸承的潤滑解決方案

通用指導：單排滾珠軸承，中等負載下每天工作8小時， 150°F (65°C)  
以下-普通鋰皂 EP2潤滑脂

速度因數 (bore in mm x rpm)	重潤滑頻率 月
50,000	36
100,000	18
200,000	6
300,000	2
400,000	1

# 滑動軸承





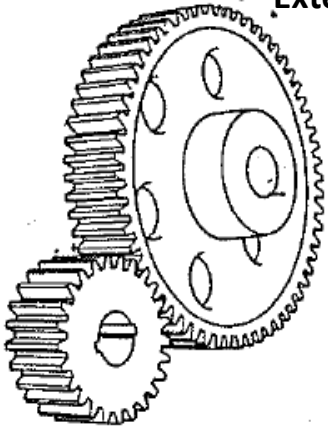
# 滑動軸承

## 滑動軸承的油潤滑

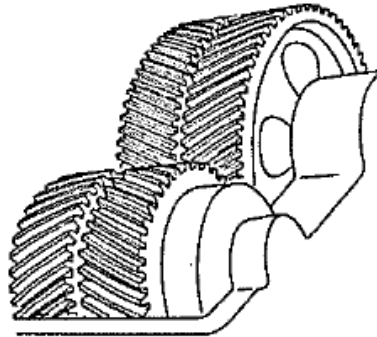
軸表面 速度 (m/min)	工作溫度範圍		
	0 – 30°C	30 – 60°C	Above 60°C
	<b>ISO</b>	<b>ISO</b>	<b>ISO</b>
Up to 60	68	220	680
60 – 150	46	150	460
150 – 300	32 to 46	100	220
300 – 760	32	46 to 68	150 to 220
Above 760	10	46	150

# 齒輪的潤滑解決方案

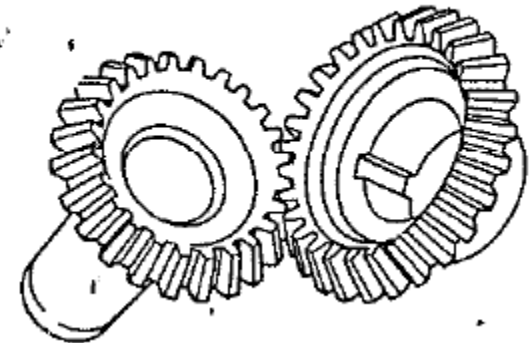
External Spur Gears



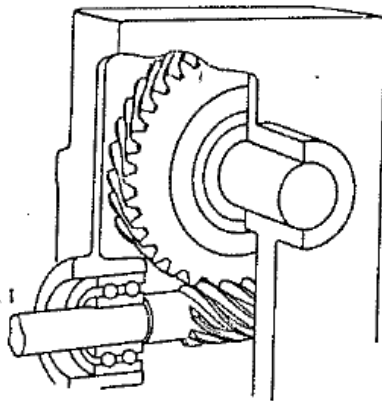
External Double Helical Gears



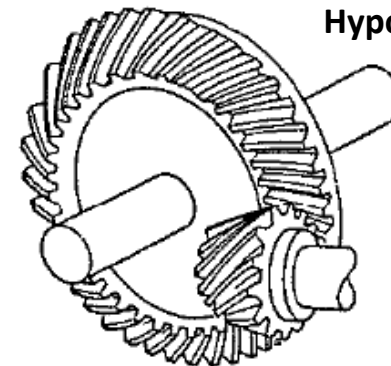
Straight Bevel Gears



Worm Gears



Hypoid Gears



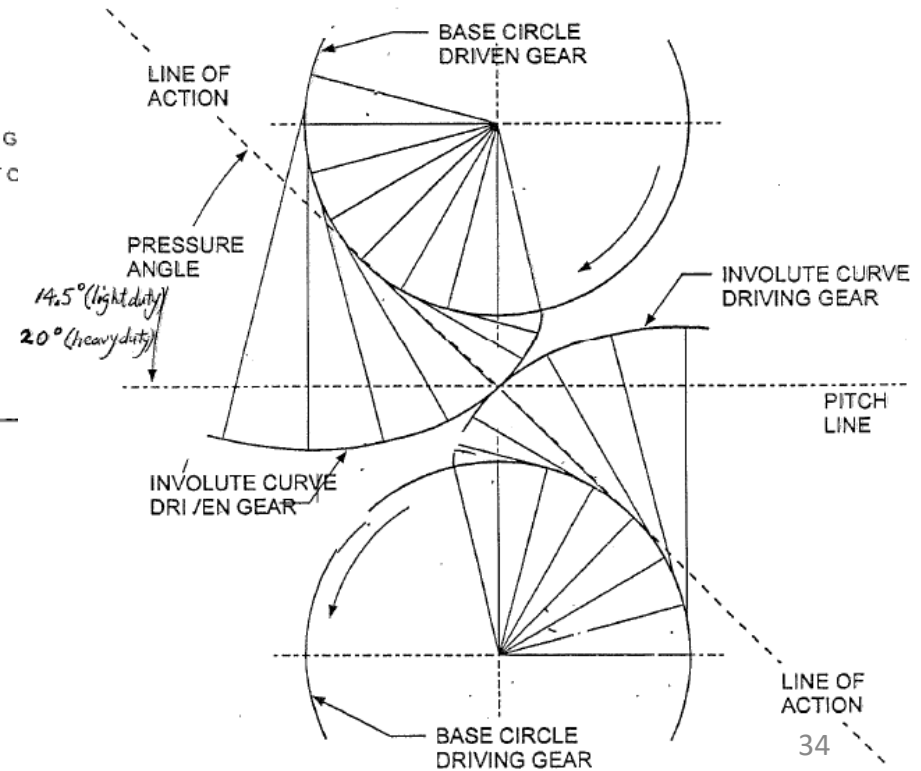
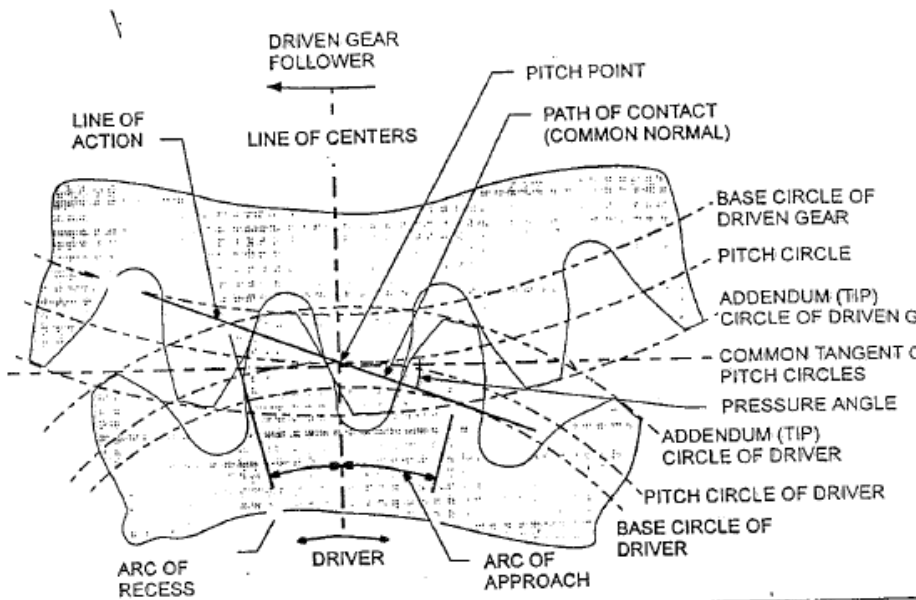
# 齒輪的潤滑解決方案

**Table 40.5** Lubrication of industrial enclosed gear drives. AGMA Lubricant Number recommendations for helical, herringbone, straight bevel, spiral bevel and spur<sup>a</sup>

<i>Centre distances: main gear, low speed</i>	<i>Ambient temperatures<sup>b</sup></i>			
	<i>(-40-78°C)</i>	<i>(-28.9 to -3.9°C)</i>	<i>(-9.4-15.6°C)</i>	<i>(10-51.7°C)</i>
	<i>Other lubricants</i>		<i>AGMA lubricant number<sup>c,d</sup></i>	
Parallel shaft (single reduction):	Automatic transmission fluid	Engine oil SAE		
Up to 8 in (200 mm)	or similar	10W-30, or similar product <sup>e</sup>	2-3	3-4
Over 8 in (200 mm) and up to 20 in (510 mm)	product <sup>e</sup>		2-3	4-5
Over 20 in (510 mm)			3-4	4-5
Parallel shaft (double reduction):				
Up to 8 in (200 mm)			2-3	3-4
Over 8 in (200 mm) and up to 20 in (510 mm)			3-4	4-5
Over 20 in (510 mm)			3-4	4-5
Parallel shaft (triple reduction):				
Up to 8 in (200 mm)			2-3	3-4
Over 8 in (200 mm) and up to 20 in (510 mm)			3-4	4-5
Over 20 in (510 mm)			4-5	5-6
Planetary gear units:				
Outside dia. of housing up to 16 in (410 mm)			2-3	3-4
Outside dia. of housing over 16 in (410 mm)			3-4	4-5
Spiral or straight bevel gear units:				
Cone distance up to 12 in (300 mm)			2-3	4-5
Cone distance over 12 in (300 mm)			3-4	5-6
Geared motors and shaft-mounted units			2-3	4-5

# 齒輪的潤滑解決方案

- 齒距線速度



# 齒輪的潤滑解決方案

**AGMA**潤滑油指數參考: 為封閉斜齒輪, 人字齒輪, 直齒錐齒輪, 螺旋錐齒輪, 直齒輪

最終減速級的齒距線速度	環境溫度°C (°F)			
	-40 to -10 (-40 to + 14)	-10 to +10 (14 to 50)	10 to 35 (50 to 95)	35 to 55 (95 to 131)
少過 <5 m/s (1000 ft/min)	<b>3S</b>	<b>4</b>	<b>6</b>	<b>8</b>
5 – 15 m/s (1000 – 3000 ft/min)	<b>3S</b>	<b>3</b>	<b>5</b>	<b>7</b>
15 – 25 m/s (3000 – 5000 ft/min)	<b>2S</b>	<b>2</b>	<b>4</b>	<b>6</b>
多過 >25 m/s (5000 ft/min)	<b>0S</b>	<b>0</b>	<b>2</b>	<b>3</b>

# 齒輪的潤滑解決方案

**Table 40.6** Enclosed cylindrical and double enveloping worm-gear drives

<i>Worm centre distance</i>	<i>Worm speeds (rev/min) up to</i>	<i>Ambient temperatures</i>		<i>Worms speeds (rev/min) up to<sup>b</sup></i>	<i>Ambient temperatures</i>	
		<i>15–60° F (–9.4–15.6° C)</i>	<i>50–125° F (10–51.7° C)</i>		<i>15–60° F (–9.4–15.6° C)</i>	<i>50–125° F (10–51.7° C)</i>
		<i>AGMA lubricant no.</i>			<i>AGMA lubricant no.</i>	
Up to and including 6 in (150 mm):						
Cylindrical worm	700	7 comp	8 comp	700	7 comp	8 comp
Double-enveloping worm	700	8 comp	8A comp	700	8 comp	8 comp
Over 6 in (150 mm) and up to 12 in (300 mm):						
Cylindrical worm	450	7 comp	8 comp	450	7 comp	7 comp
Double-enveloping worm	450	8 comp	8A comp	450	8 comp	8 comp
Over 12 in (300 mm) and up to 18 in (460 mm):						
Cylindrical worm	300	7 comp	8 comp	300	7 comp	7 comp
Double-enveloping worm	300	8 comp	8A comp	300	8 comp	8 comp
Over 18 in (460 mm) and up to 24 in (610 mm):						
Cylindrical worm	250	7 comp	8 comp	250	7 comp	7 comp
Double-enveloping worm	250	8 comp	8A comp	250	8 comp	8 comp
Over 24 in (610 mm):						
Cylindrical worm	200	7 comp	8 comp	200	7 comp	7 comp
Double-developing	200	8 comp	8A comp	200	8 comp	8 comp