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Capped PAGs European Product Manager

Technical Service & Development

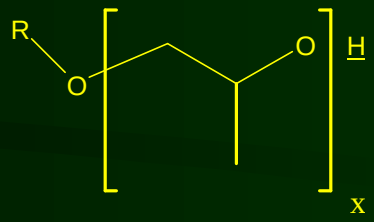
Laporte Performance Chemicals UK Ltd

High Performance Polyalkylene Glycol Lubricants for CO_2 based air-conditioning / refrigeration systems.

Common Uncapped PAGs - Air-conditioning (Auto HFC)

Water Insoluble:

(R - most commonly Me, Bu)

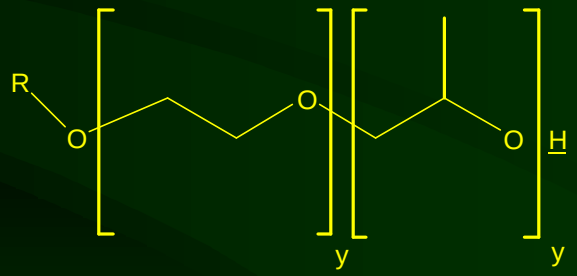


(Terminating Hydroxide)

Homo-polymer

Water Soluble:

(R - most commonly Me, Bu)



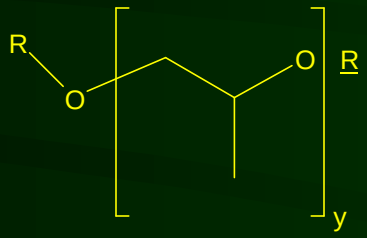
(Terminating Hydroxide)

Random Co-polymer

Common Capped PAGs - Air-conditioning (Auto HFC)

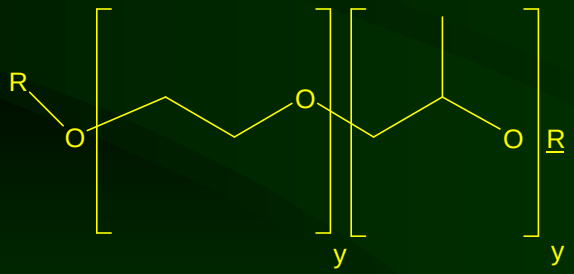
“Symetrically” capped PAGs:

Homo-polymer



(Terminating Alkyl - commonly Me)

Random Co-polymer



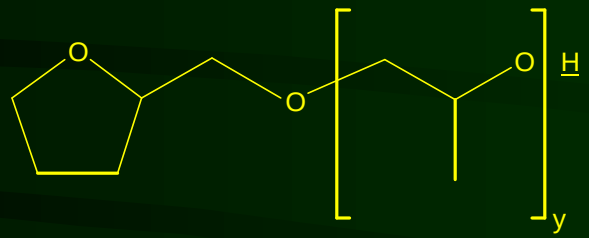
(Terminating Alkyl - commonly Me)

(Most commonly terminating R = Initiating R, as both ends simultaneously capped)

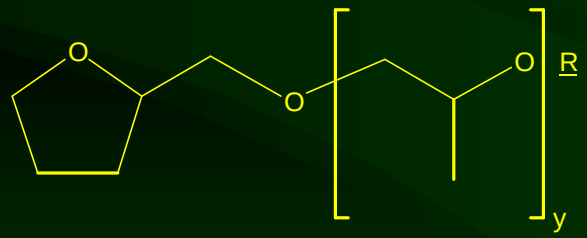
Common Capped PAGs - Refirgeration / Air-conditioning (HFC)

“Asymetrically” capped PAGs:

Homo-polymer



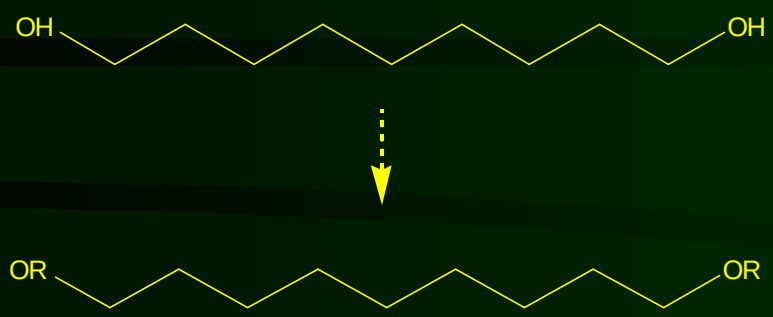
(Terminating Group - hydroxyl)



(Terminating Alkyl - commonly Me)

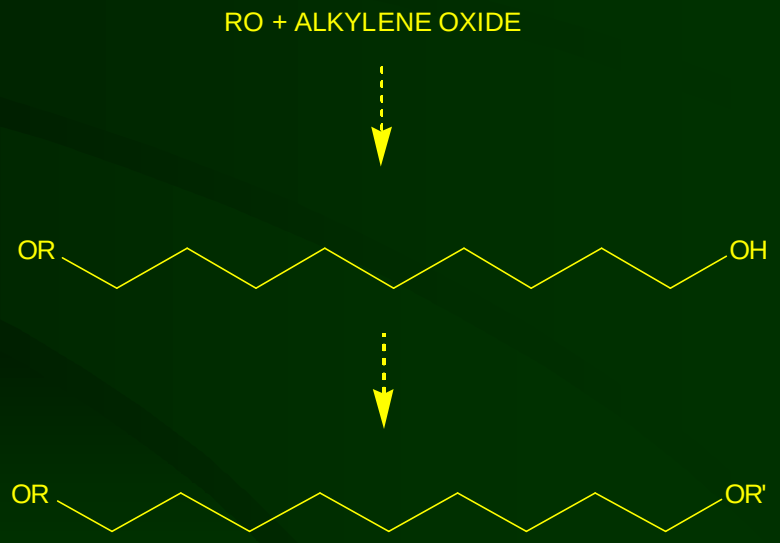
Terminating R [1] Initiating R, two stage manufacturing process)

Capping Summary



Method A - single stage

Method B - two stage

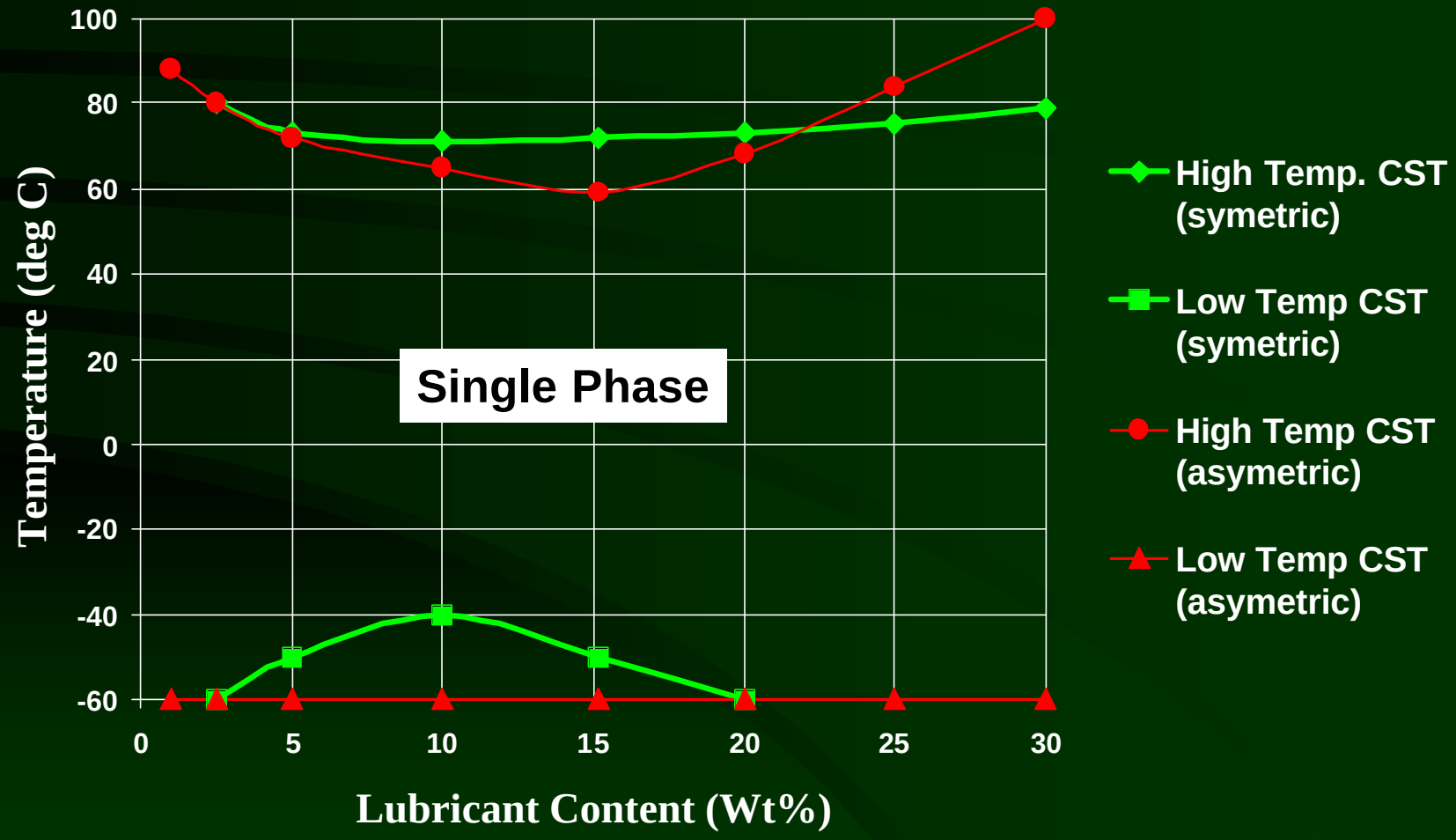


Performance advantages of asymetrically capped PAGs

(compared with symetrically capped PAGs and uncapped PAGs)

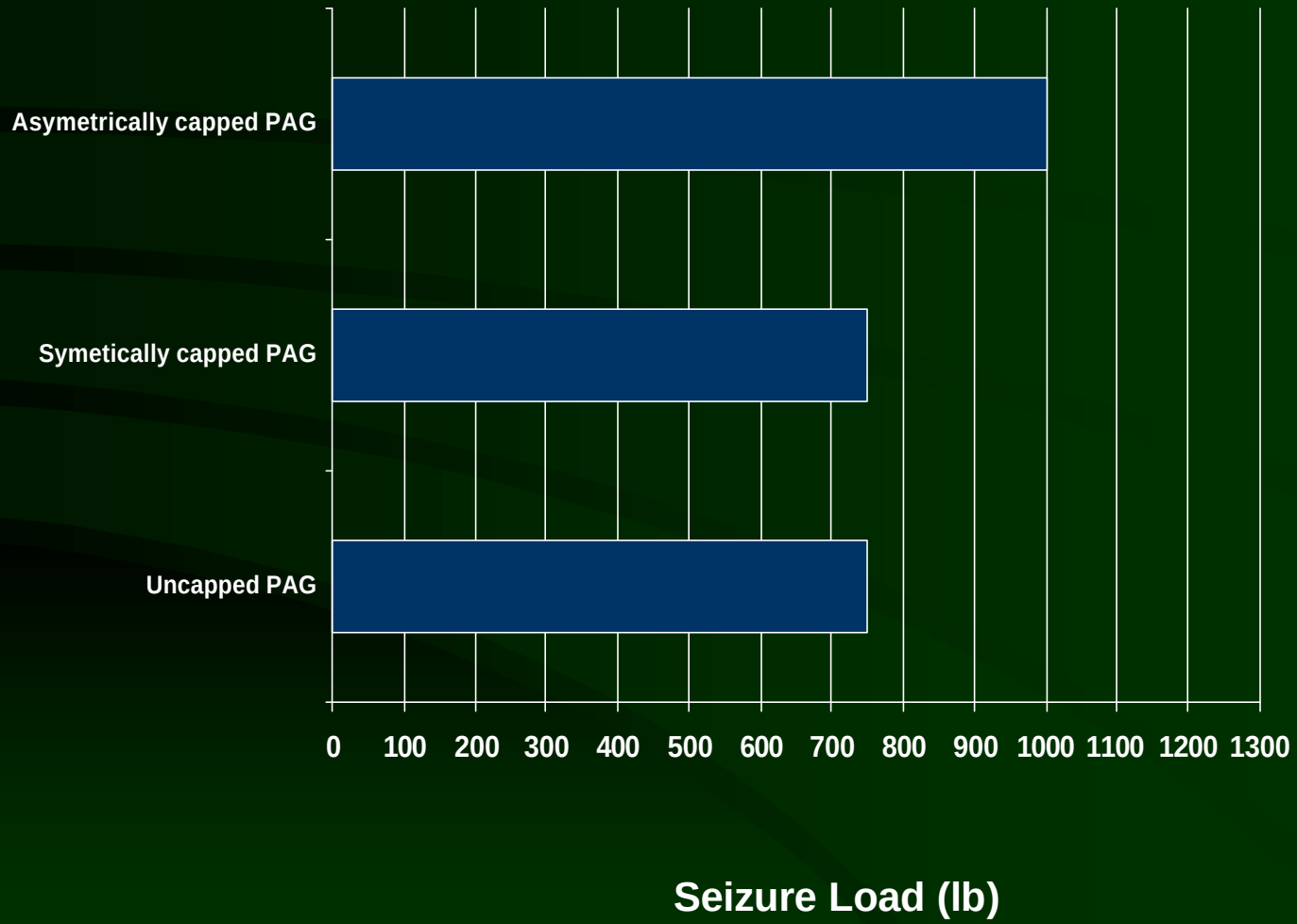
- Improved HFC miscibility
- Enhanced Extreme Pressure / Antiwear properties

Symetric and asymetric capped PAGs - R134a miscibility property.



Effect Of Capping On EP Characteristics Of PAGS

Modified Falex Test (R-134a atmosphere).
Iron pin / Iron block, Procedure ASTM D3233.

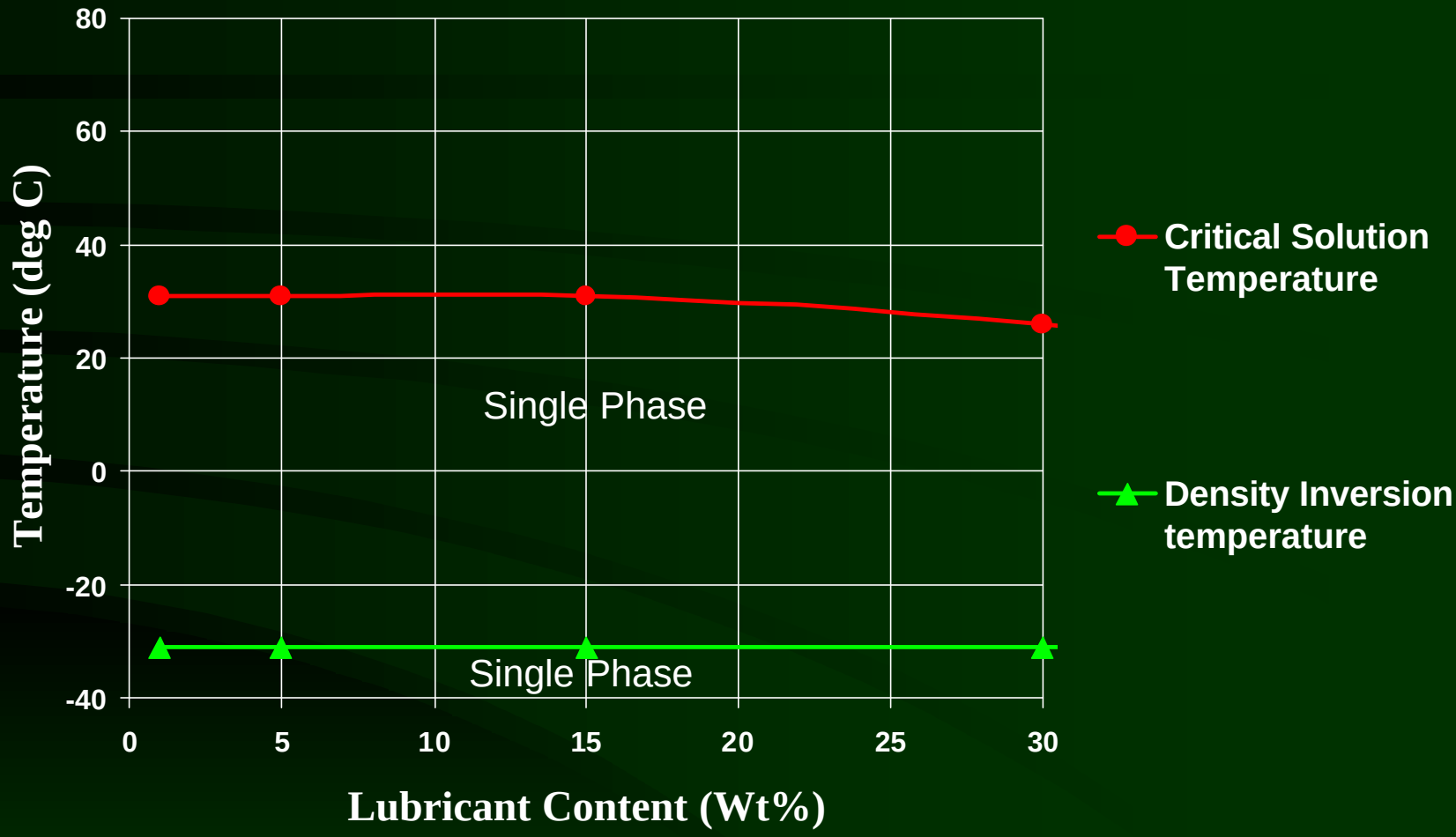


Capped PAGs - Automotive Air-conditioning (CO_2)

Modification of R / R' to enhance performance under conditions of CO_2 compressor :

- Enhanced CO_2 miscibility
- Enhanced Extreme Pressure / Antiwear property
- Stability under elevated temperature / pressure conditions

Asymetric capped PAG - CO_2 miscibility property, (ISO 46 Grade)

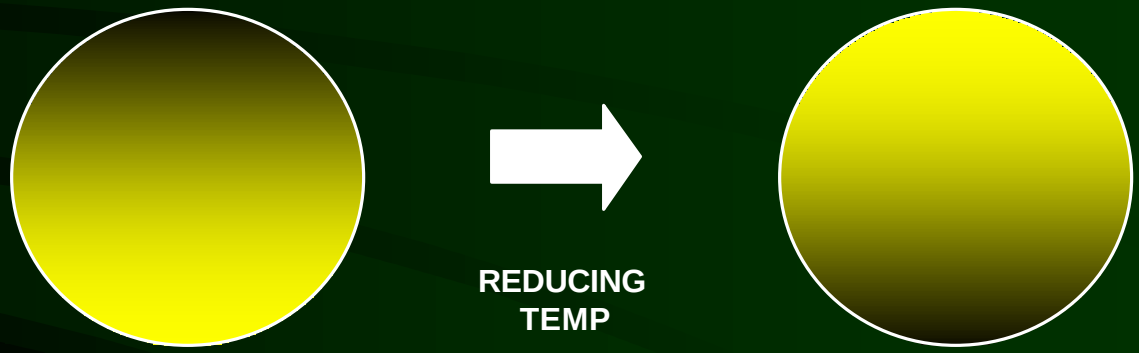


Asymetric capped PAG - CO_2 miscibility property.

No Low temperature CST

Density Inversion observed:

CO_2 rich solution



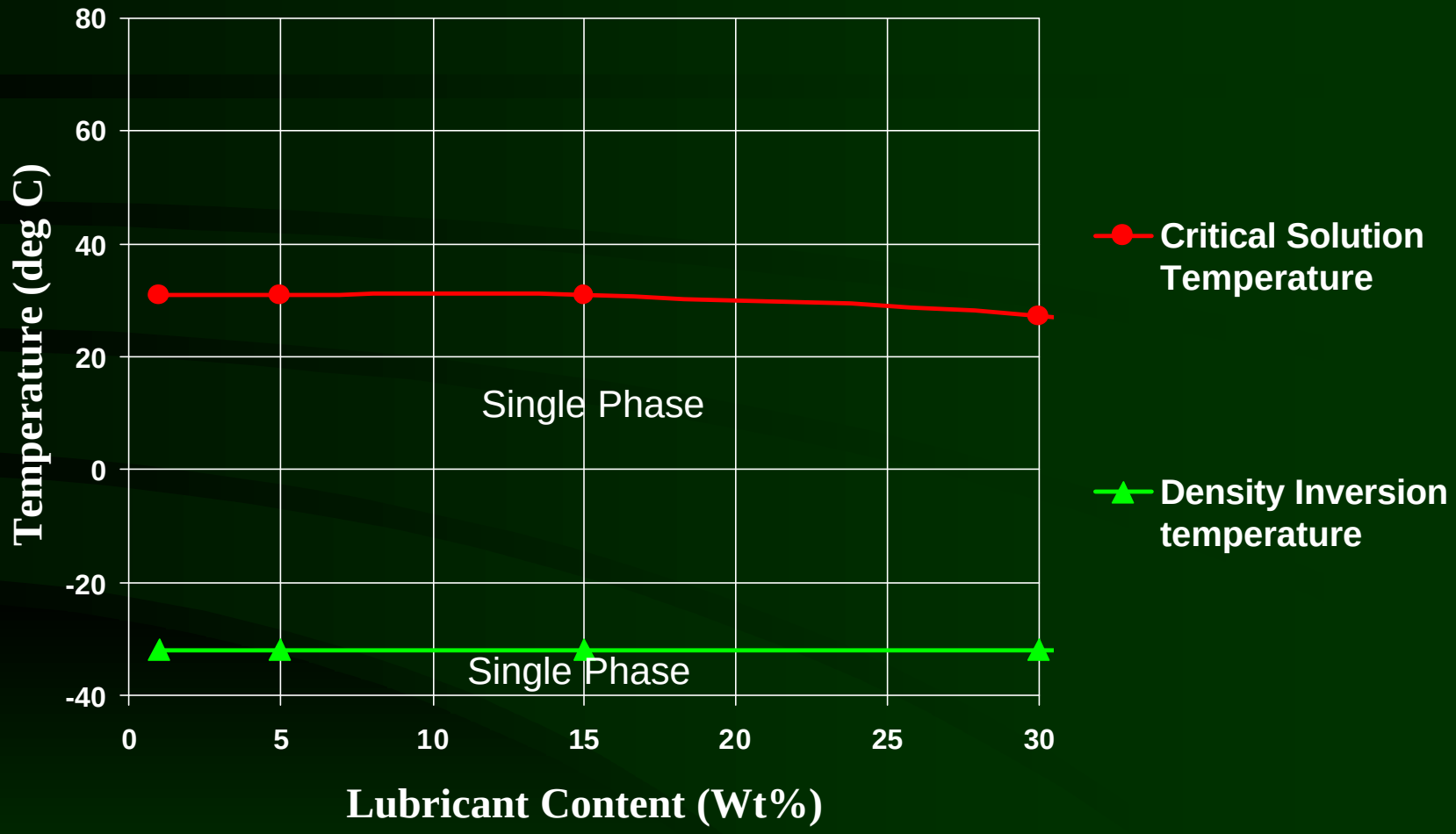
lubricant rich solution

REDUCING TEMP

lubricant rich solution

CO_2 rich solution

Asymetric capped PAG - CO_2 miscibility property, (ISO 100 Grade)



Asymetric capped PAG - CO_2 miscibility property.

- Miscibility with CO2 enhanced compared with uncapped and symetrically capped PAGs.
- Viscosity reduction associated with miscibility minimal compared with POE.
- Lubricity property not disadvantaged by improved miscibility.

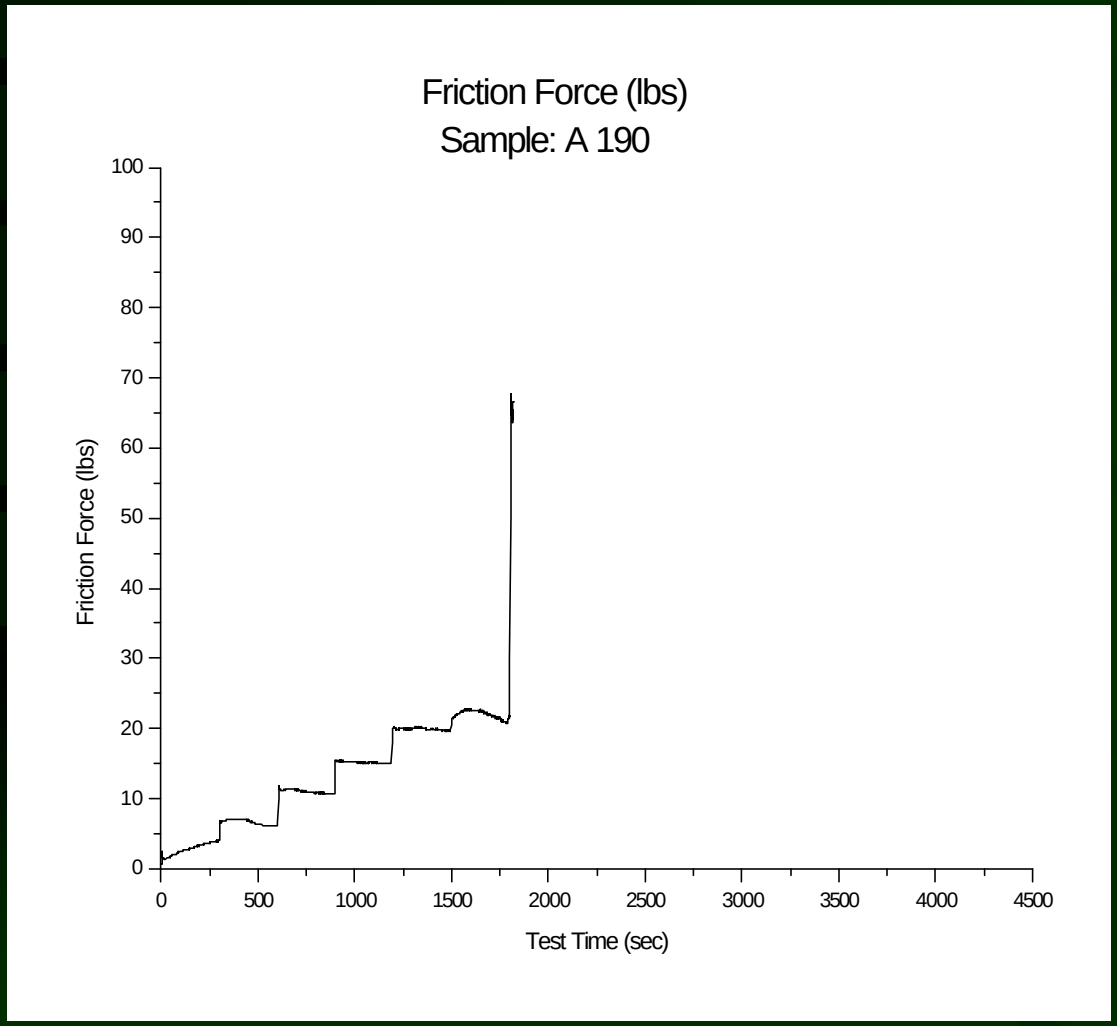
Asymetric capped PAG - lubricating property in CO_2 systems.

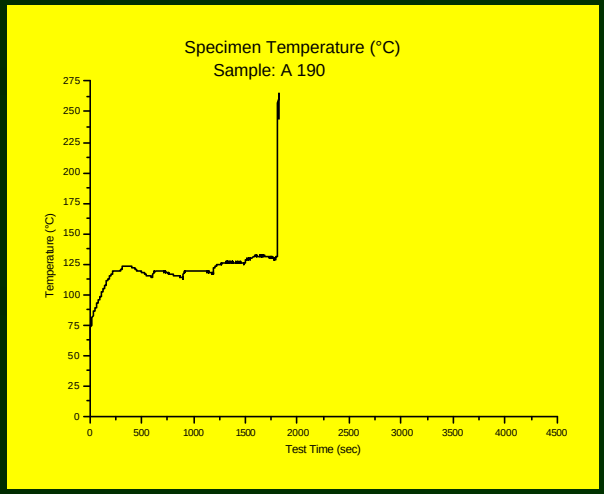
- Trans-critical CO2 systems - higher load-bearing requirements.

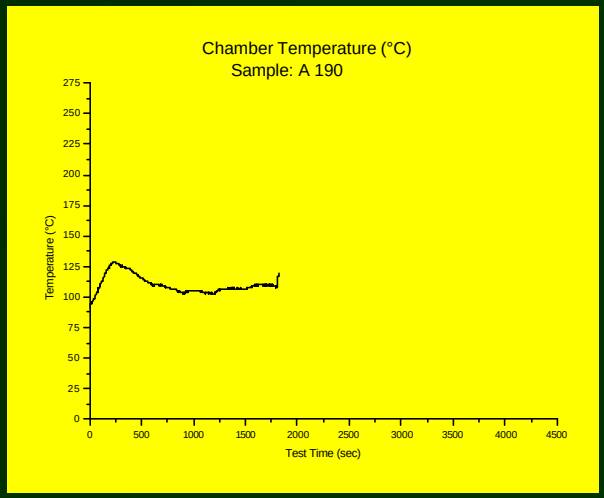
- Falex Block-on-Ring procedure:

Load steps:	50lb steps, followed by 20lb steps
Rotation:	600 rpm
Atmosphere:	CO_2
Overpressure:	10 bar (150psi)
Step duration:	5 minutes
Temperature:	90ºC minimum
Ring / Block:	Steel

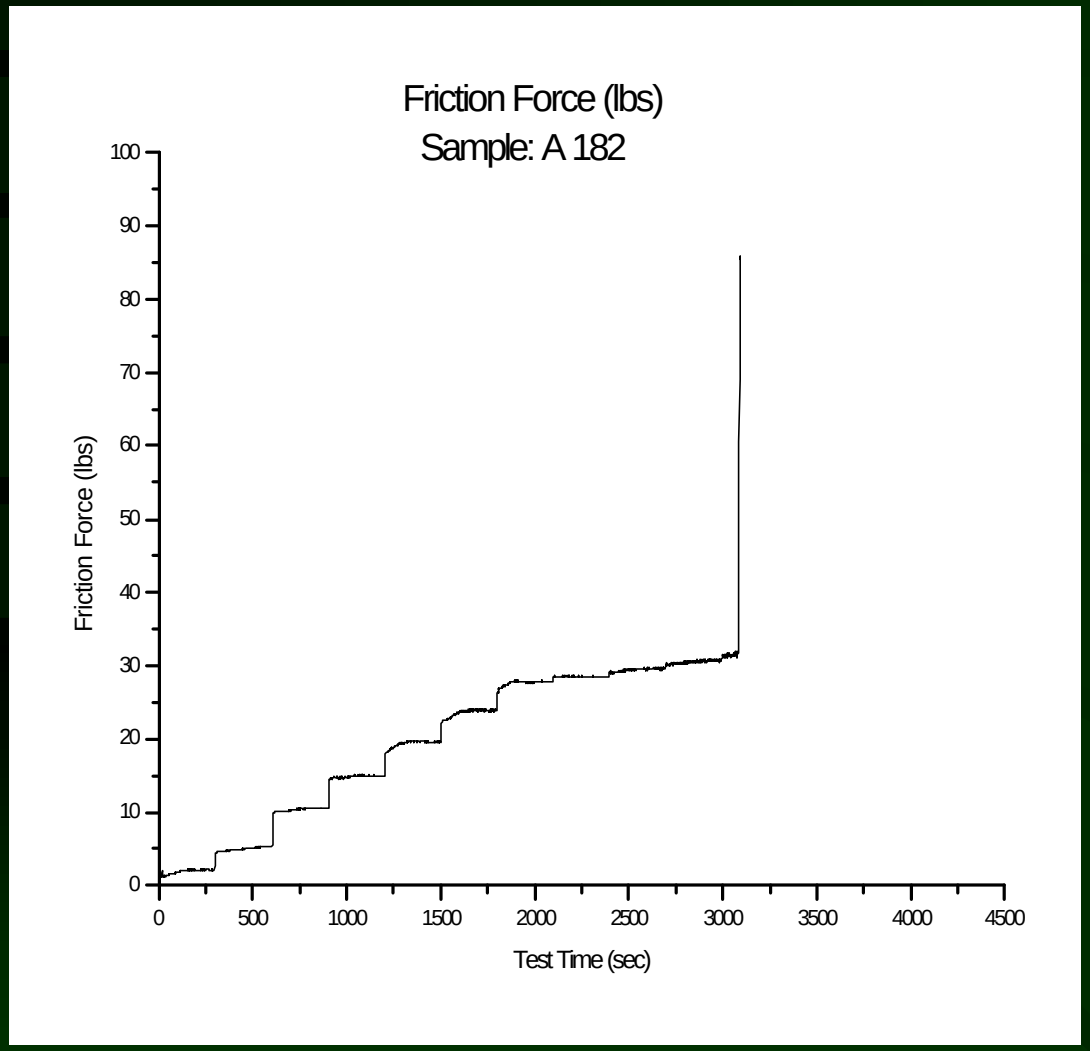
Symetric capped PAG - lubricating property in CO_2 systems.

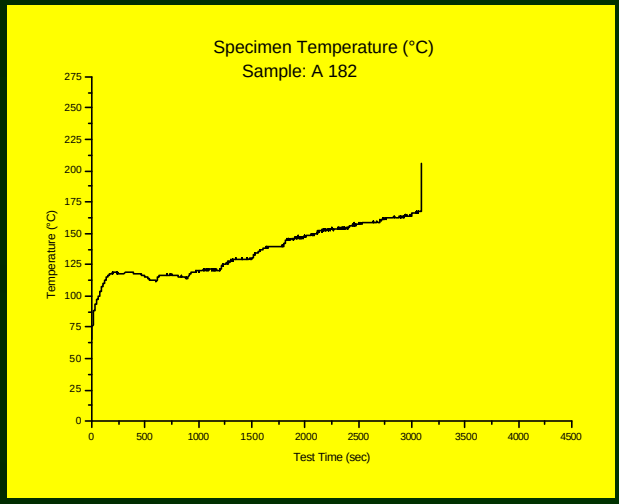


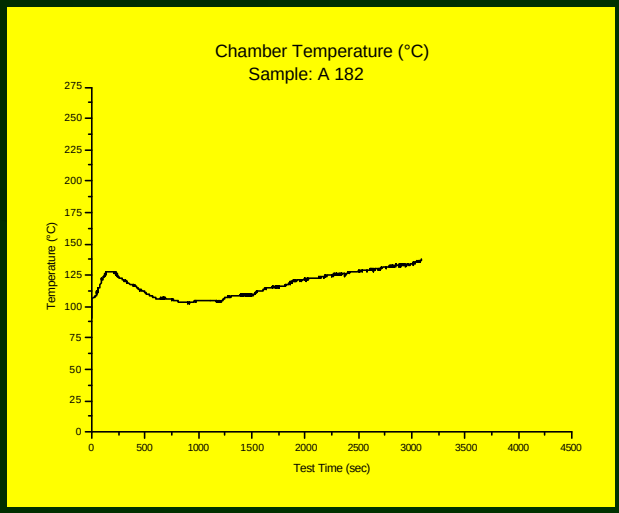




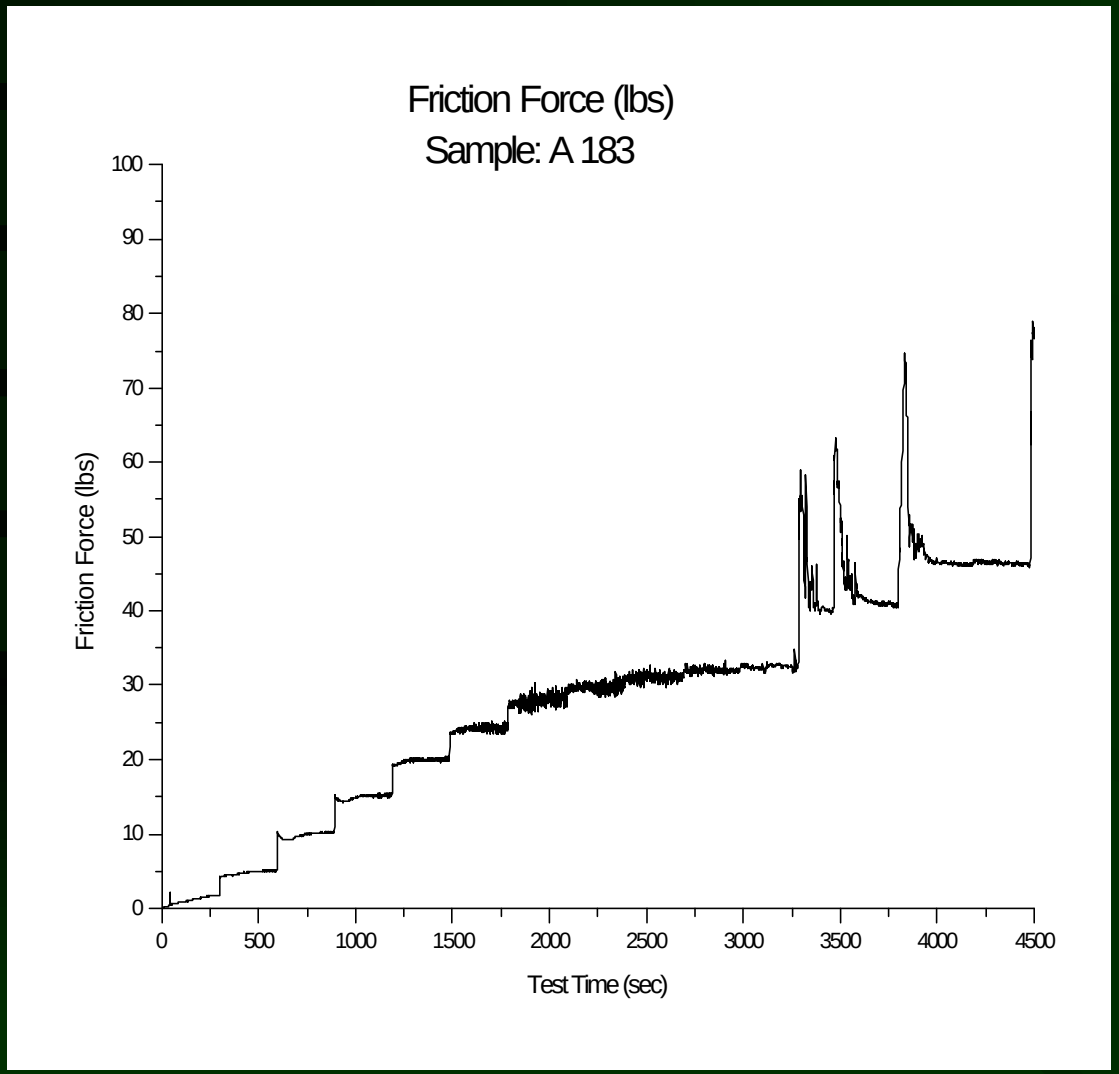
Asymetric capped PAG - lubricating property in CO_2 systems.

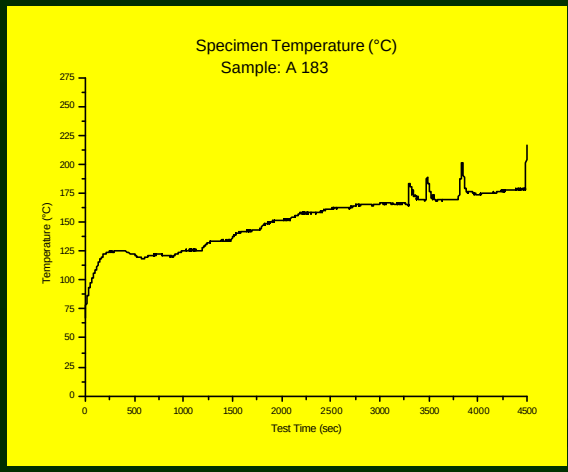


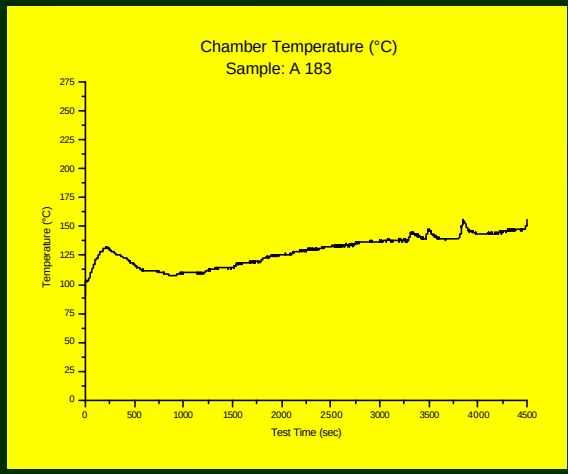




Asymetric capped PAG (+EP/AW) - lubricating property in CO_2 systems.



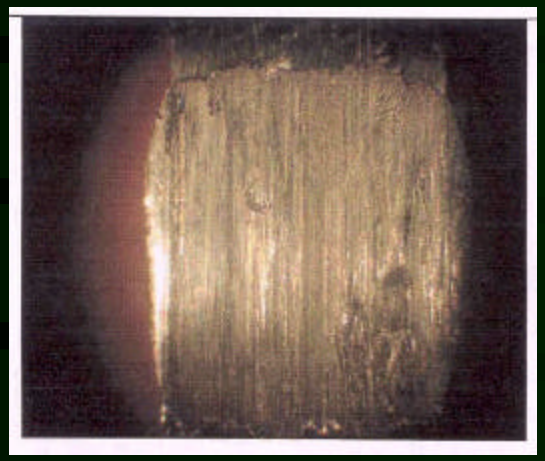
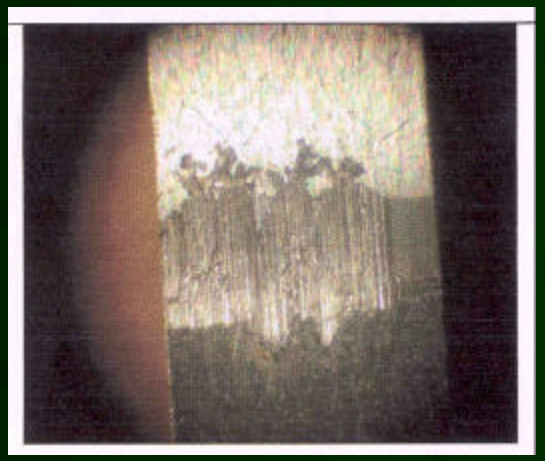
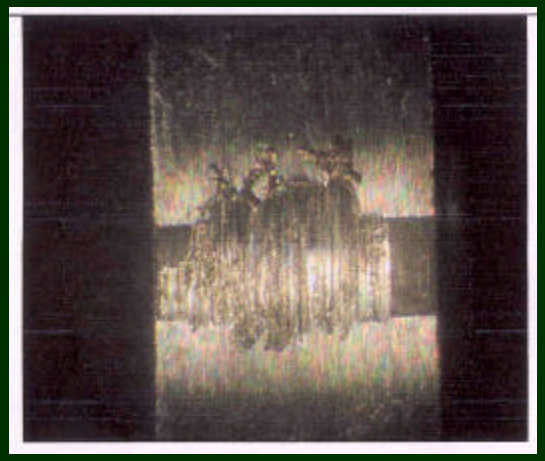
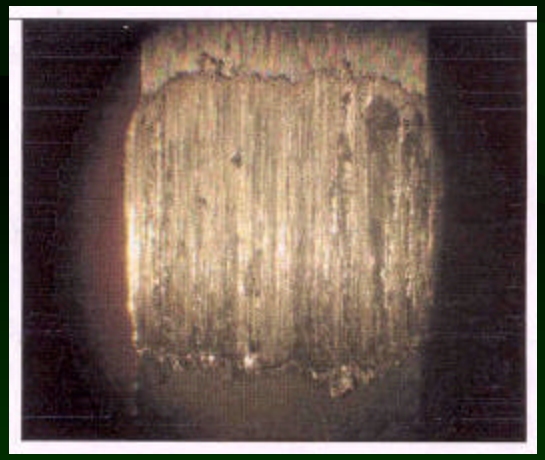
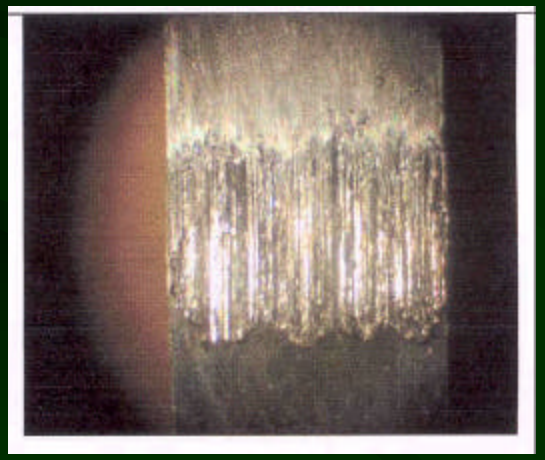




Capped PAGs - lubricating property in CO_2 systems.

Falex Block-on-Ring Summary:

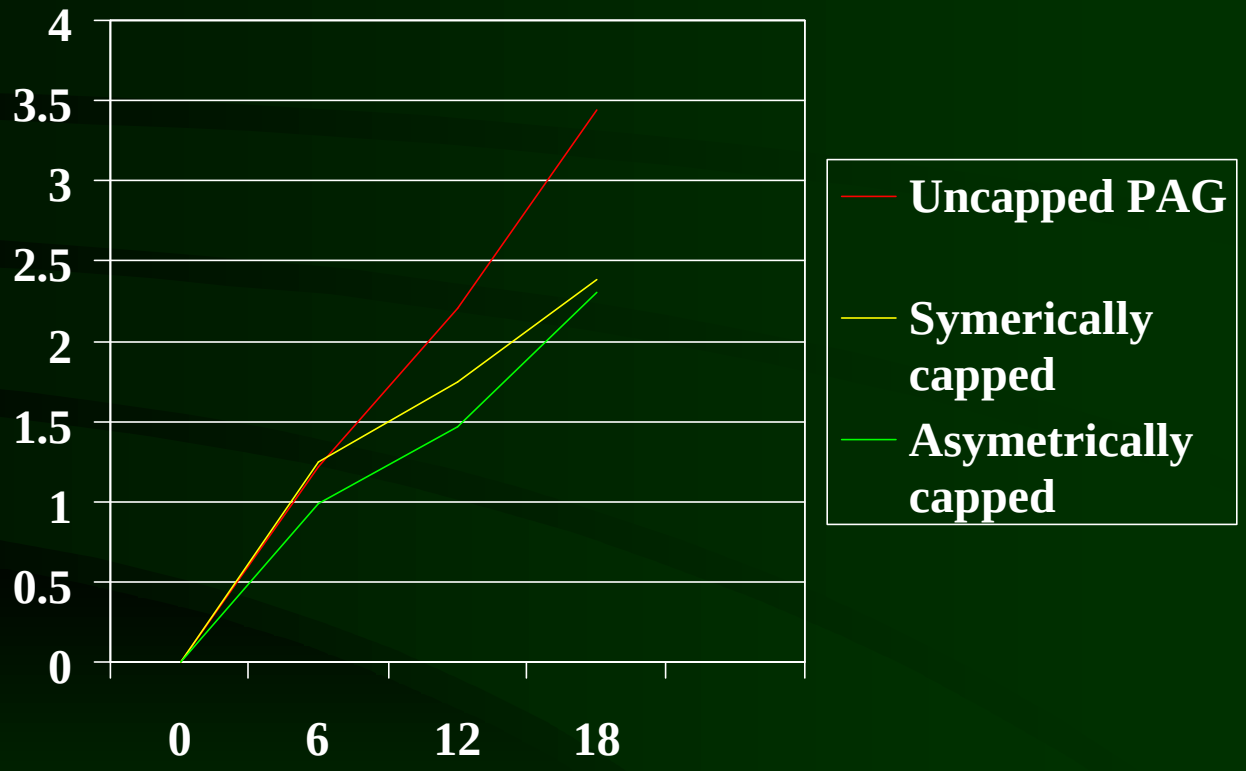
Symetric capped PAG - lubricating property in CO_2 systems - Block wear.

A190 (**Symetric capped**)	A182 (**Asymetric capped**)	A183 (**Asymetric capped +EP/AW**)
		
50lb load steps	50lb load steps	50lb load steps
		
20lb load steps	20lb load steps	20lb load steps

Capped PAGs - thermal stability in CO_2 systems.

Modified IP 48:

CO_2 environment:	(1atmos pressure)
CO_2 flow rate through sample:	15litre/hr
Temperature:	200ºC
Time:	18 hours



Conclusions

- **Novel cappingtechnology enables the synthesis of PAG type lubricants with improved CO_2 miscibility, lubricity and thermal stability properties, of particular interest for CO_2 compressor applications.**

- **A flexible “capping” process can be utilised to allow structure modification and hence performance optimisation for the future refrigerant technology developments.**