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Steps to efficient laboratory simulation of wear and lubrication issues in industrial components

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Field – Bench / Laboratory test

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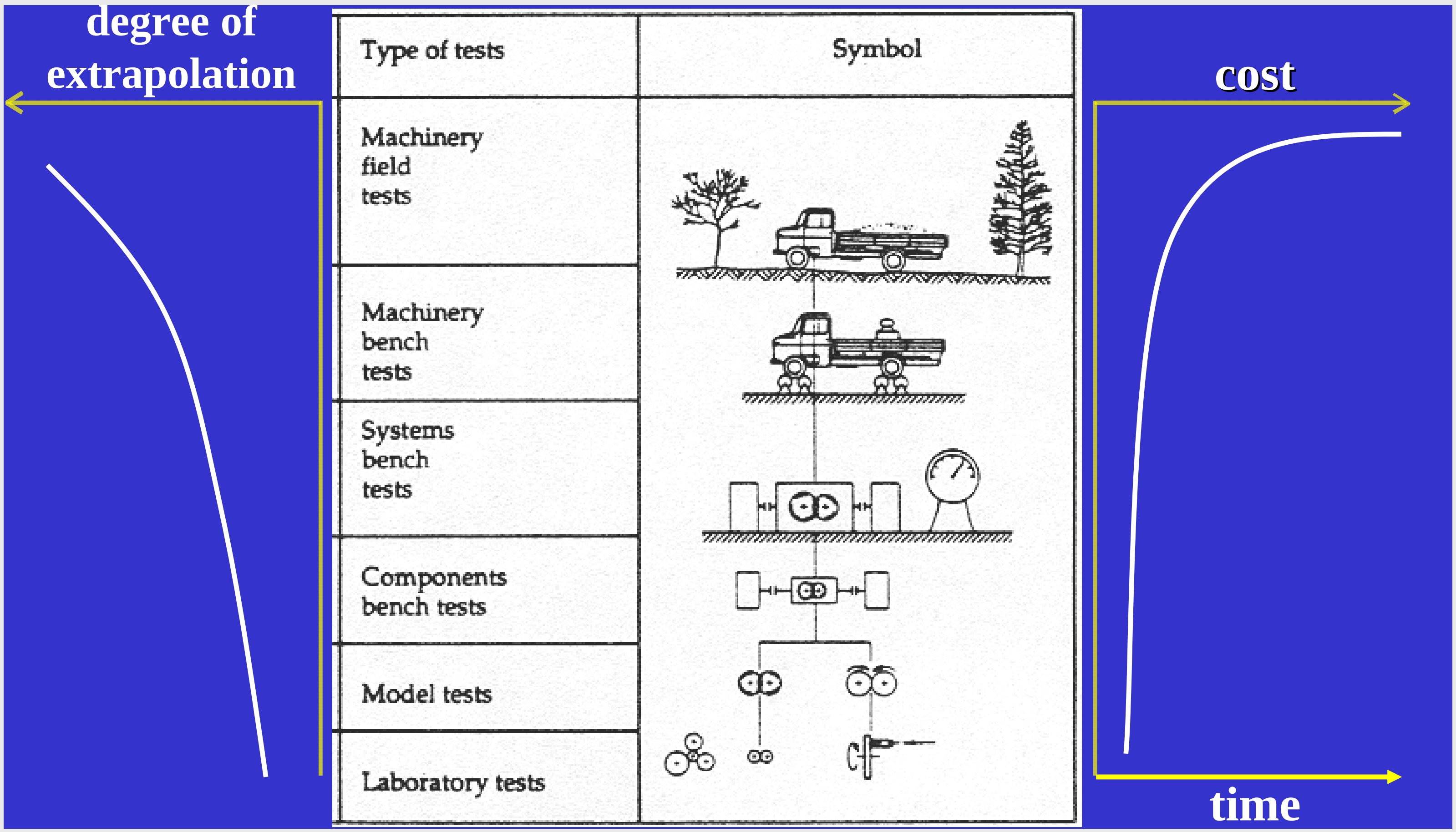

Bench / Laboratory testing

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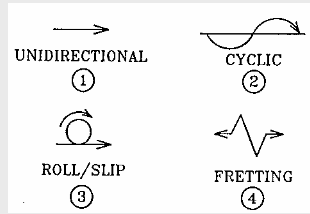
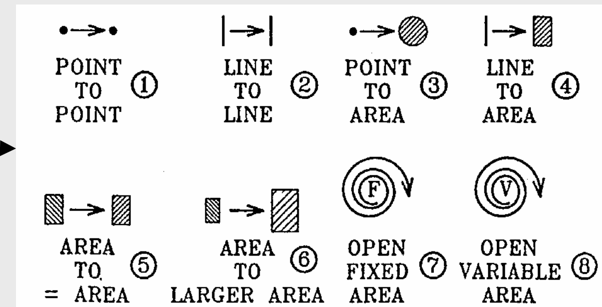
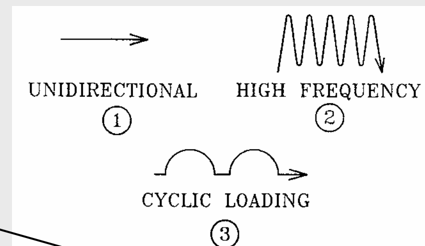
Advantages	Economic	Specimen price Test price Time
	Technologic	Parameter control Statistical analysis Measurements
Dangers	aspect/parameter	affects
Accelerated testing	Higher loads	Galling Fatigue Adhesion
	Higher speed	Fatigue Thermal input Lubrication regime
Lubrication	Small, stationary volume	Starvation Stratification Degradation
Geometry changes	Smaller sample	Thermal input (Oxidation, phase transformations)
	Simpler shape	Lubrication regime

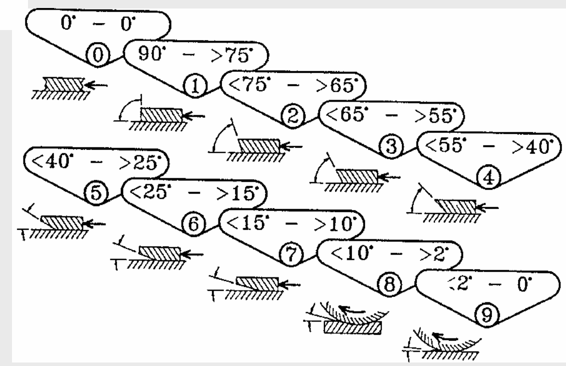
Description of field problem

- contact velocity
- contact area
- contact pressure
- entry angle





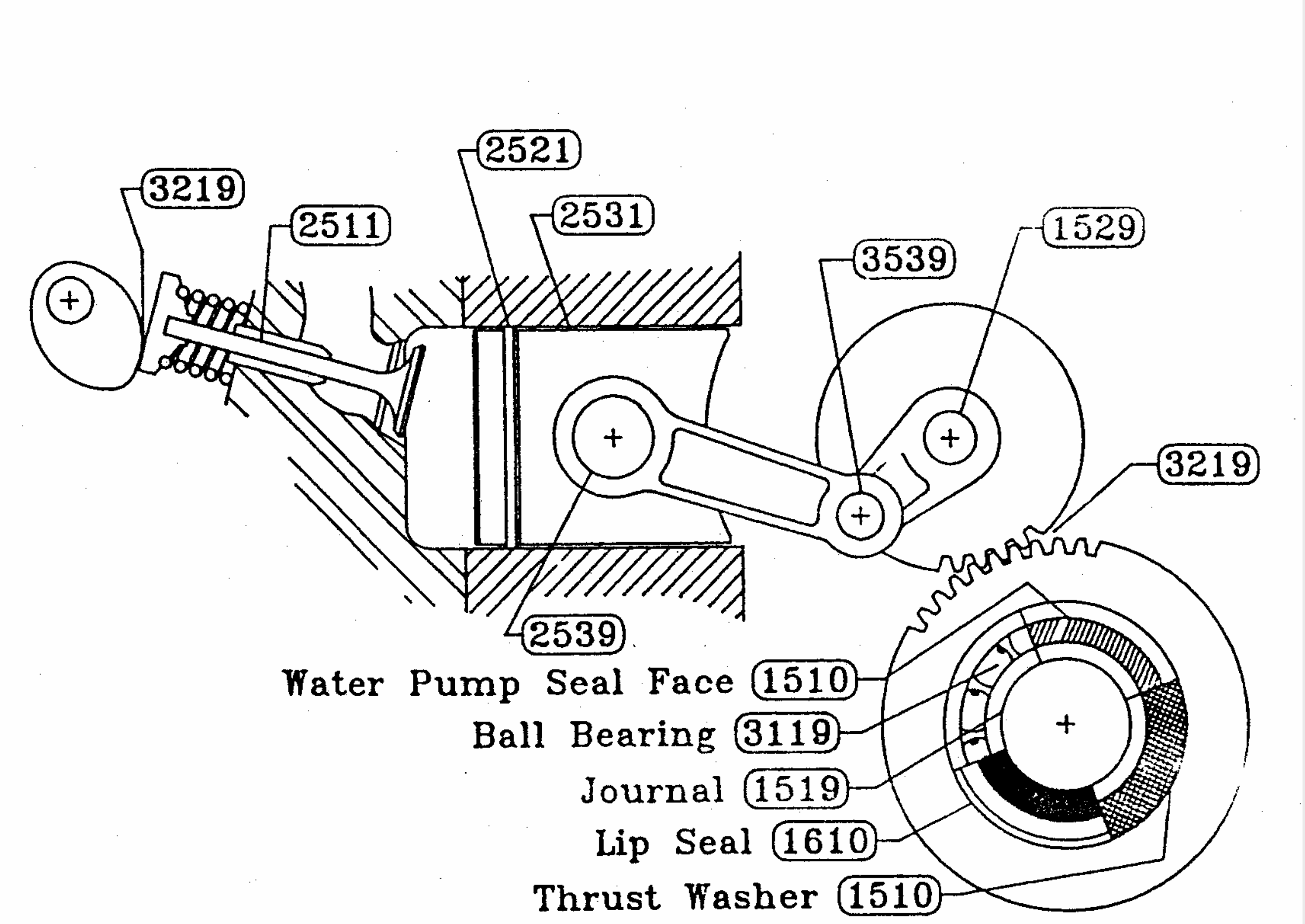




TAN : **T**ribological **A**spect **N**umber

choice of test geometry

Lab scale testing statergy



Lab scale testing strategy

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1. Field problem

TAN Code
X Y Z W

2. Bench test geometry

TAN Code
X Y Z W

3. Select :

contact pressure
speed
lubricant, environment
materials, hardness, finish

conformity with wear mechanism

Case study

Effects of CO_2 on lubricating properties of esters and glycols

- **Effective lubrication for compressor bearings**
- **Due to international regulations, CO_2 is used instead of HCFC refrigerants**
- **Negative effect of CO_2 on lubricity was observed in practise : A deviation from lab scale simulations!**
- **Pin & vee, Almen-Wieland tests with CO_2 bubbling**

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Pin-on-vee results

Pin&Vee Block test, CO_2 bubbling, steel-steel

Lubricant	Failure load ASTM 3233-B (lbs)
Polyol ester without additives (POE-0)	750
Polyol ester with additive package B (POE-2)	750
Polyol ester with additive package D (PAG-2)	1000

Over estimated results !

Experimental approach

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- **Application of interest is rotary compressor,**
- **Typical geometry can be simplified to a sliding line contact (cylinder inside a larger cylinder)**
- **Sliding occurs unidirectional and the load on the line contact is nominally constant.**
- **Utilizing the TAN-selection code, several geometries are proposed: Block-on-Ring, Timken, O- Ring test or Pin & Vee Block test**

Block-on-ring set up

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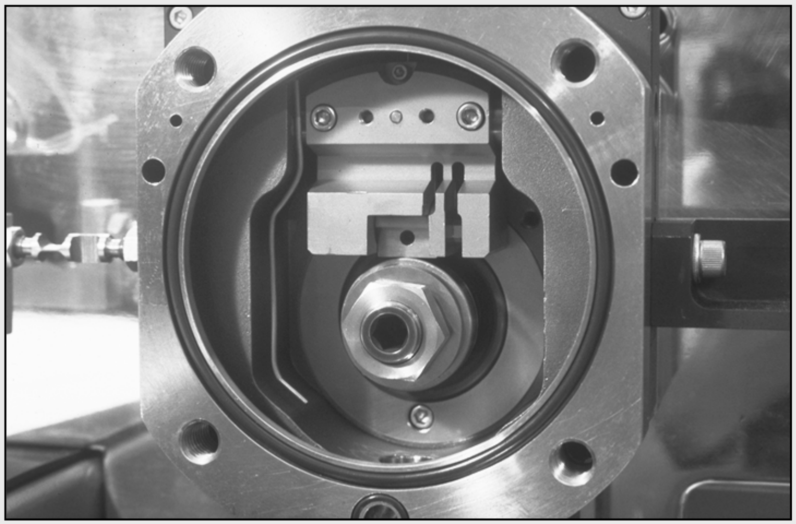

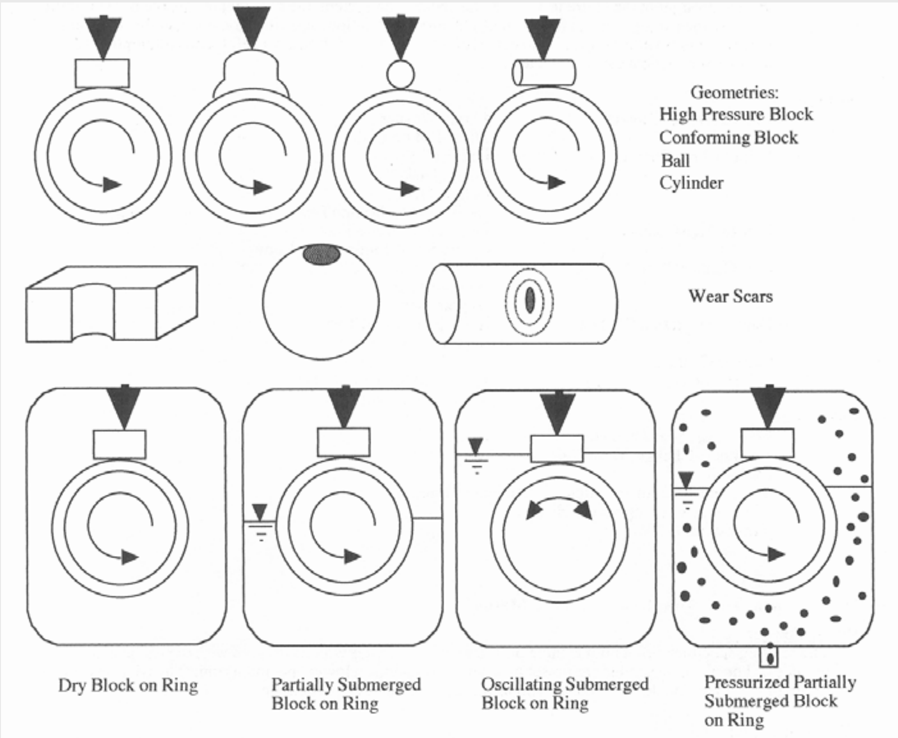

- **Polyol ester (POE) and Polyalkyl glycol (PAG) oils with & without additives**
- **S10 steel ring (SAE 4620 caburized) on H30 (SAE 01 steel)**

Block-on-ring tests

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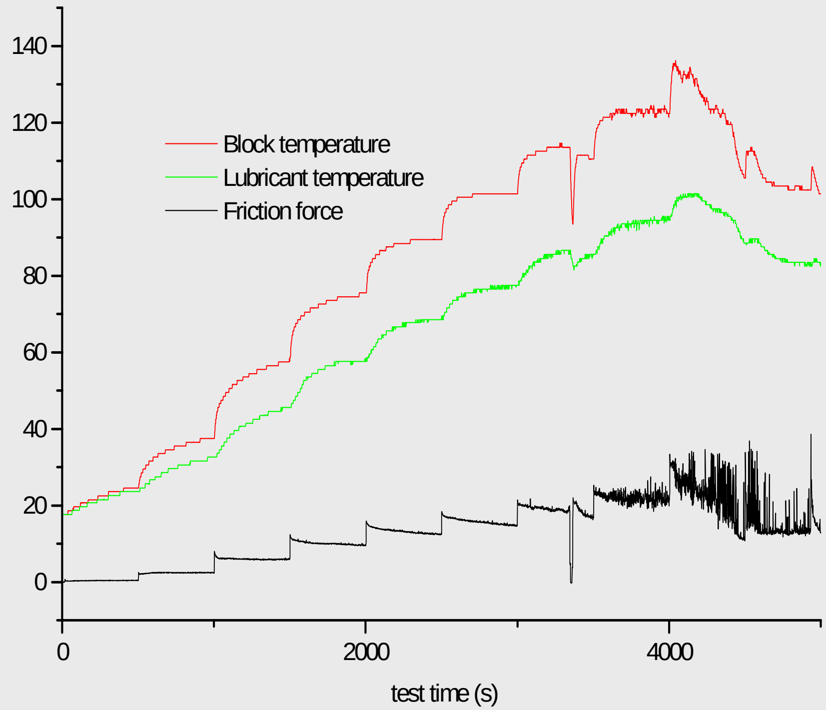
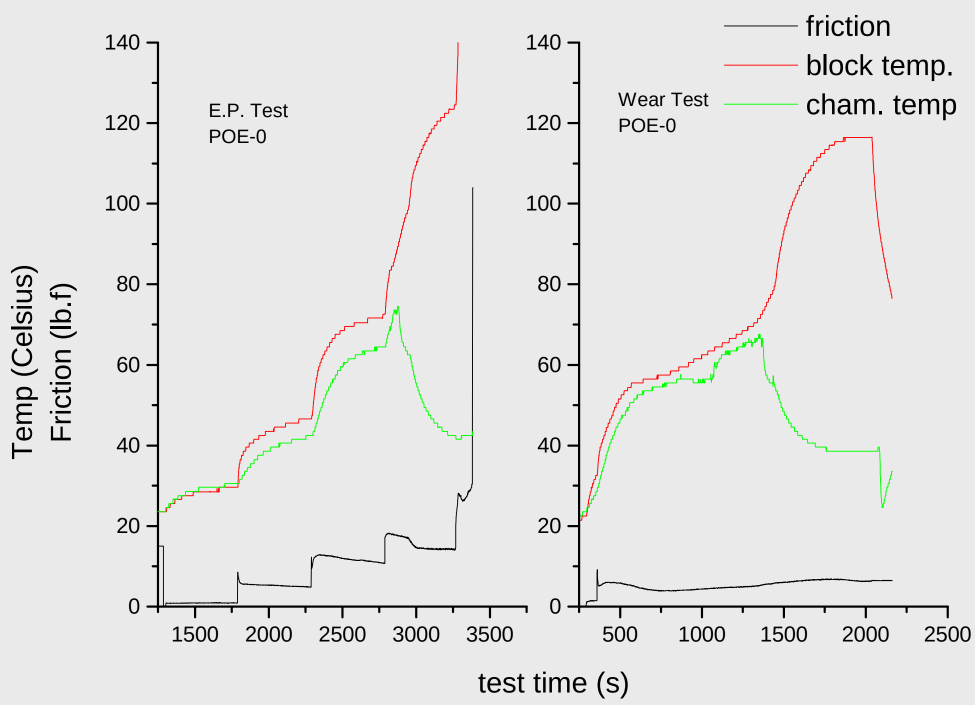
In air



With pressurised CO_2



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Block-on-ring EP results

Failure loads of POE and PAG in air and CO_2, steel blocks against steel rings

Lubricant	Atmospheric (A) or CO_2	Failure load (seizure)
POE-0	A	>600
POE-0	CO_2	200
POE-2	A	>600
POE-2	CO_2	>300
PAG-2	A	> 300
PAG-2	CO_2	250

Evolution of wear with time

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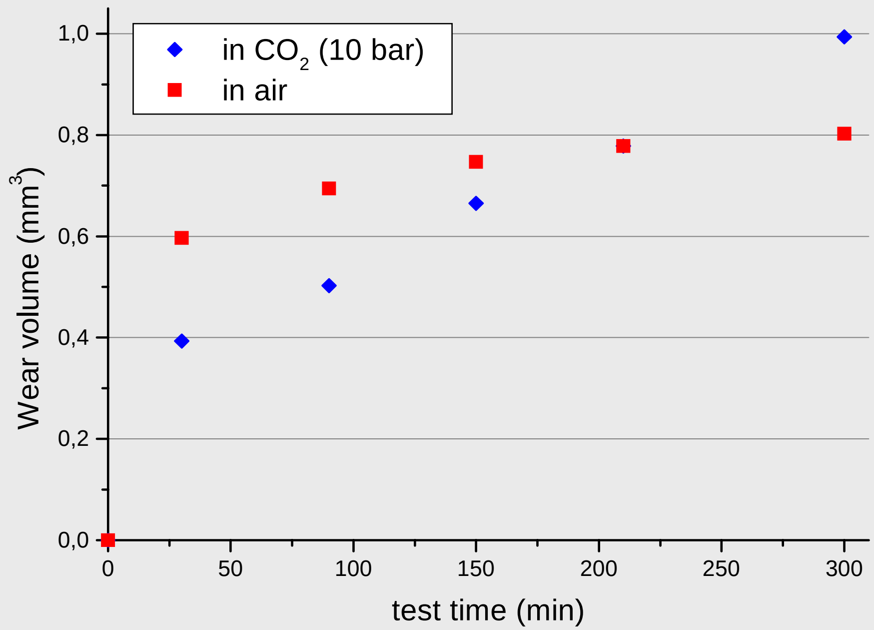
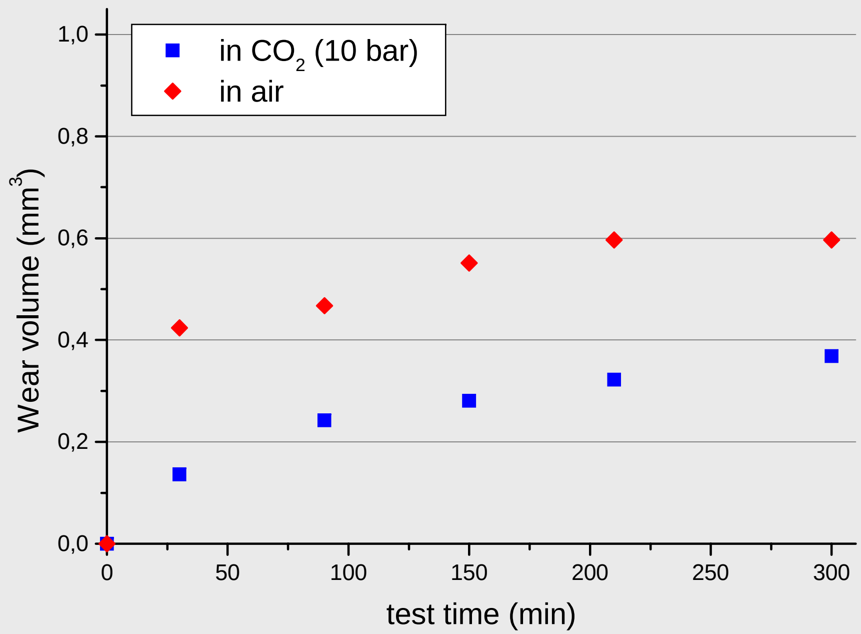
Test at 100 lbs, 30-300 min, 600 rpm

Evolution of wear volume in POE-0

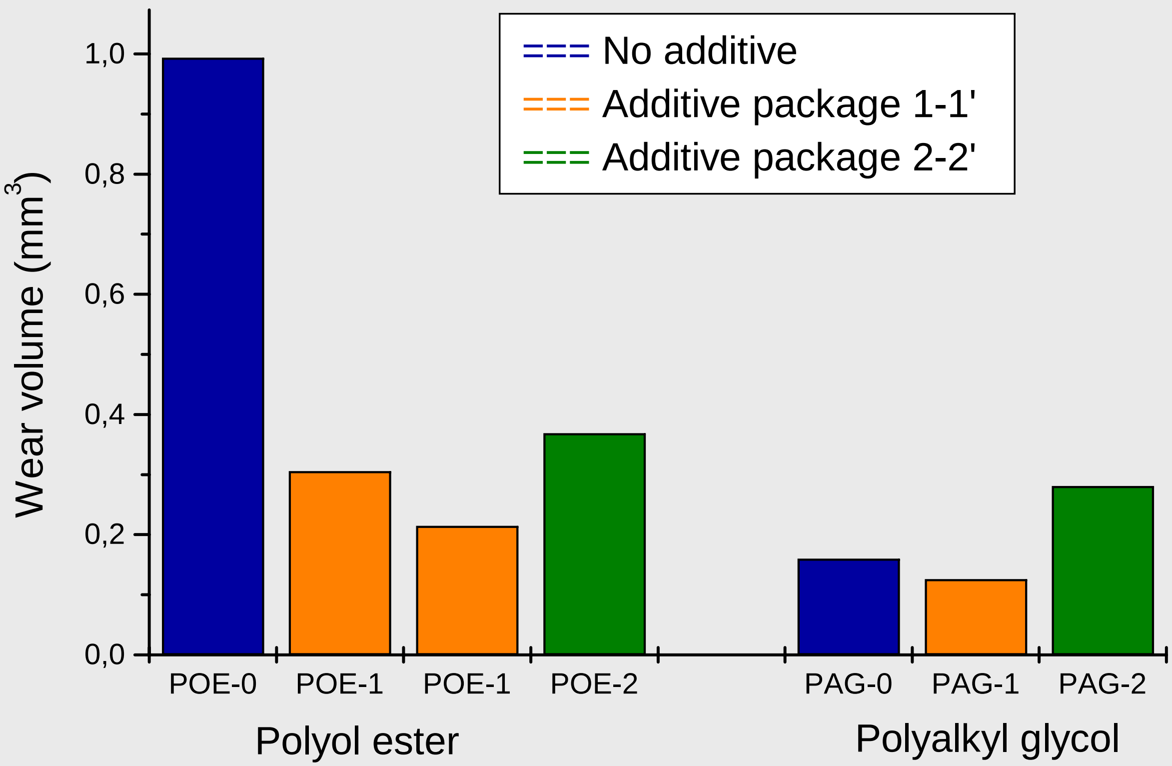


Evolution of wear volume in POE-2



Wear volume on blocks

Wear loss on steel blocks



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Conclusions

- **It is necessary to simulate tests with pressurised CO_2**
- **In POE thermally induced effects affect tribological properties. At high temperatures CO_2 expands out of lubricant, gas bubbles are created that physcially interfere with heat transfer**
- **Although running-in is reduced with CO_2, steady state wear could be large (detrimental to compressor performance)**
- **Efficient laboratory simulation of wear and lubrication needs smart selection of test parameters and may not be based on trail and error**

Thank you !

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