



Energy Efficiency Forum
Bucharest October 8 2015

Energy efficiency and Lubrication

Energy lives here™

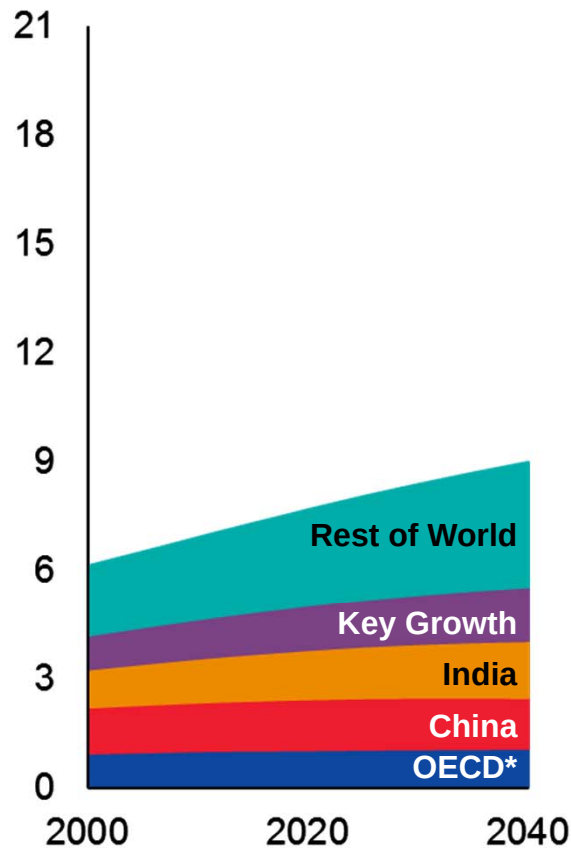
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This presentation includes forward-looking statements. Actual future conditions (including economic conditions, energy demand, and energy supply) could differ materially due to changes in technology, the development of new supply sources, political events, demographic changes, and other factors discussed herein (and in Item 1A of ExxonMobil's latest report on Form 10-K or information set forth under "factors affecting future results" on the "investors" page of our website at www.exxonmobil.com). This material is not to be reproduced without the permission of Exxon Mobil Corporation.

Global Progress Drives Demand

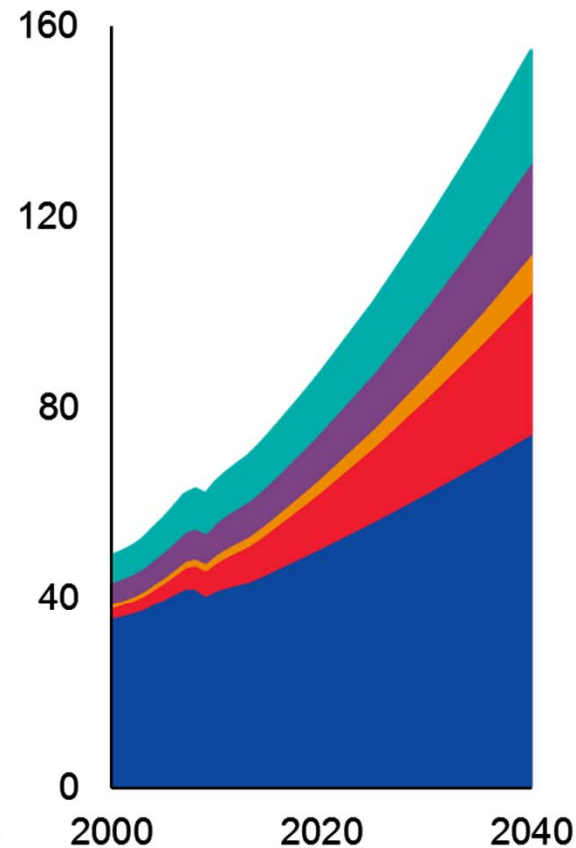
Population

Billion



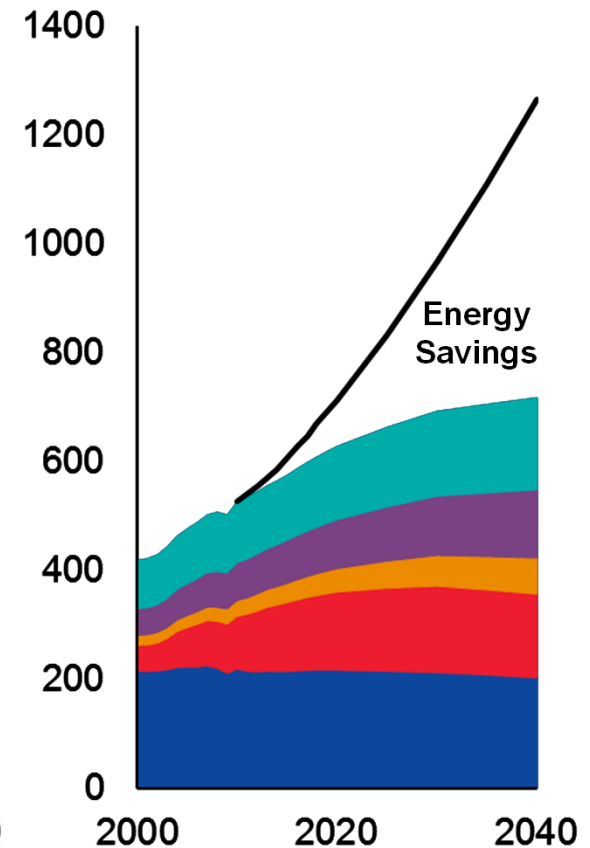
GDP

Trillion 2010\$



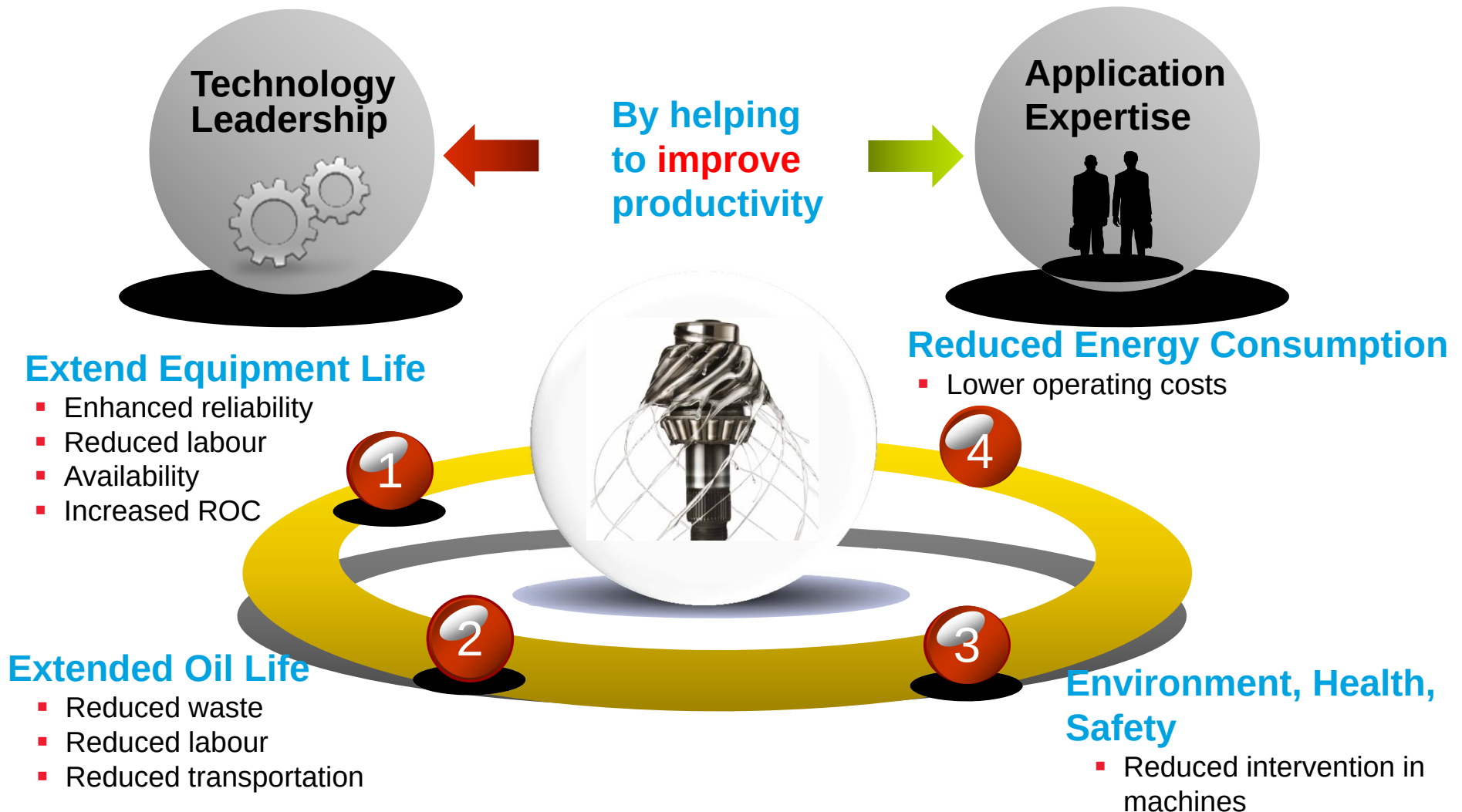
Energy Demand

Quadrillion BTUs



**Mexico and Turkey included in Key Growth countries*

Our objective: improve productivity





INTRODUCTION

Energy Efficiency / Concept

2 relevant cases studied

- Mobil SHC 600 / Mobil SHC Gear
- Mobil DTE 10 Excel



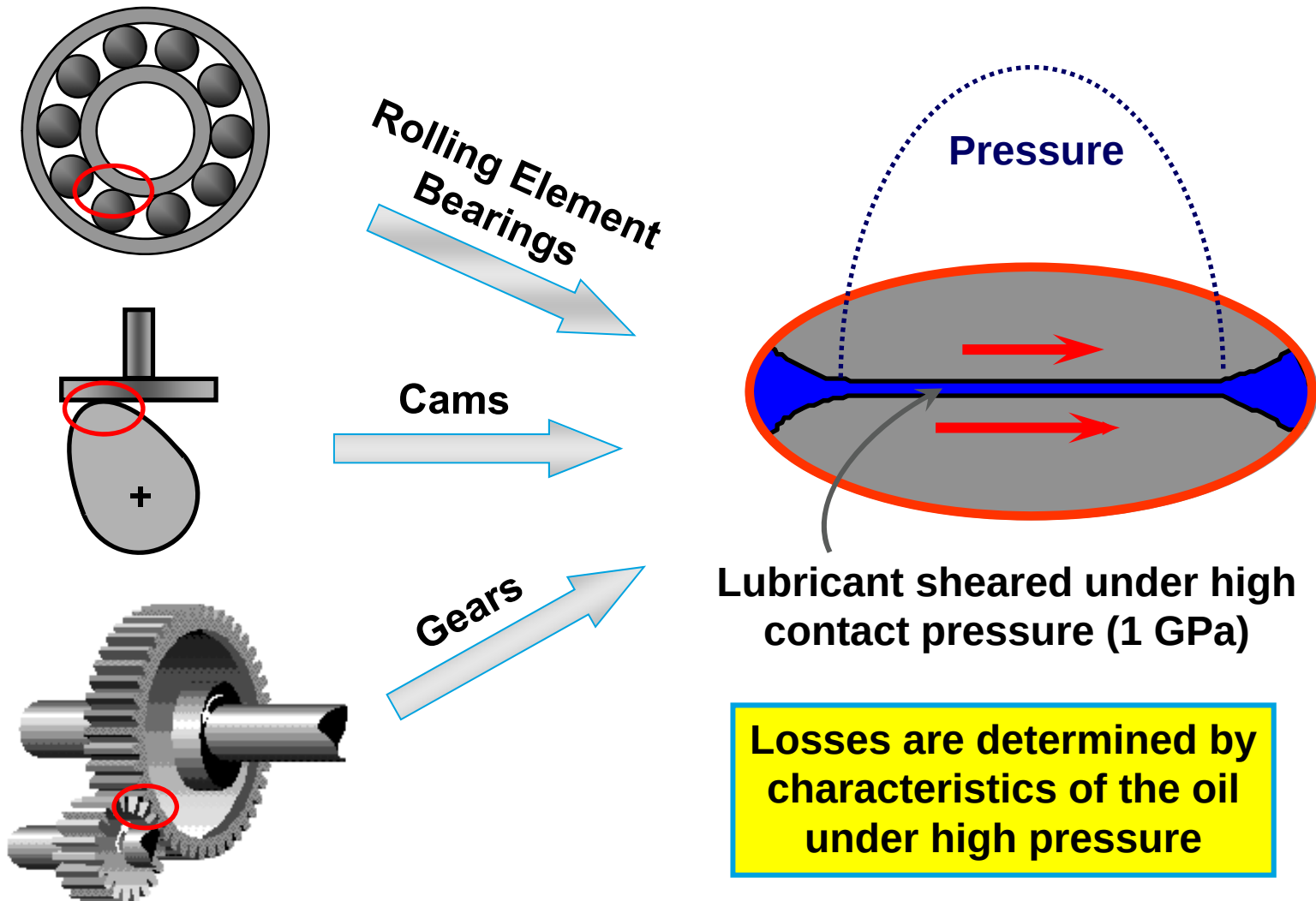
Mobil SHC 600 and Mobil SHC gear



**Industrial bearings and gear oils
for high temperature and
heavy duty application**



Elastohydrodynamic Lubrication (EHL)

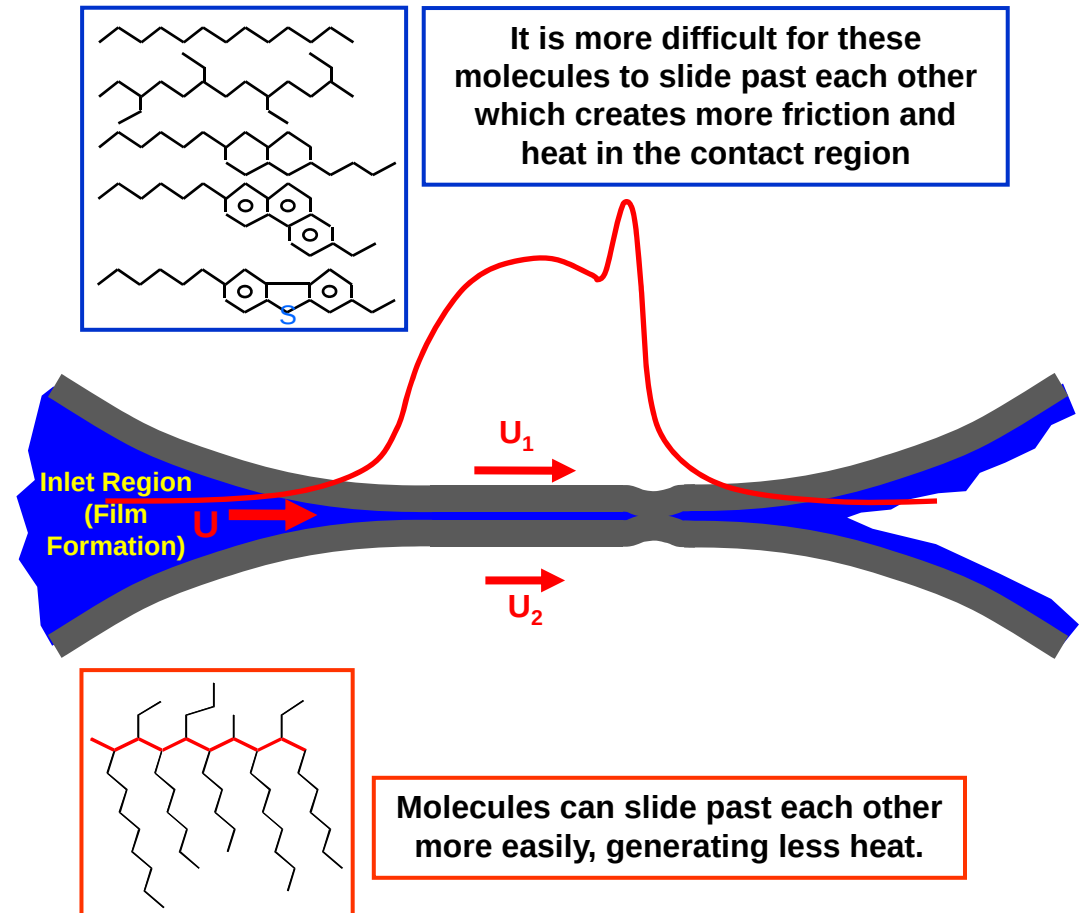


Traction Fundamentals

Mobil SHC 600 / Mobil SHC Gear



- Traction is dependent on molecular structure.
- **Mineral oil stocks** exhibit higher P-V coefficients due to their combination of aromatics, paraffins, et. al.
- **Synthetics (PAO)** are based on paraffin structures and exhibit lower P-V coefficient - hence lower traction.



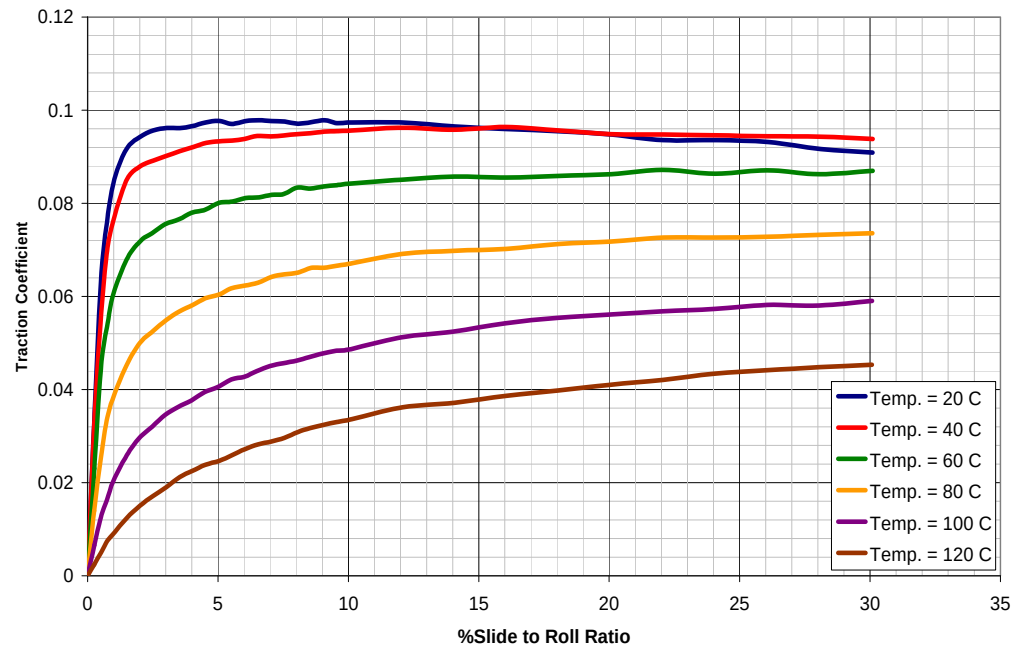
Lower traction leads to less resistance in the EHL contact zone
Resulting in energy efficiency benefit and lower operating temperatures

Mini Traction Machine (MTM) Mobil SHC 600 / Mobil SHC Gear



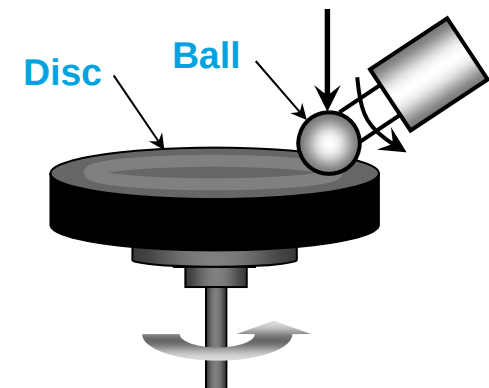
Traction Curves at Various Conditions

Traction Curves - Speed = 2 m/s, Pressure = 0.75 GPa



EHL Traction Curves are constructed under High Contact Load and Contact Pressure

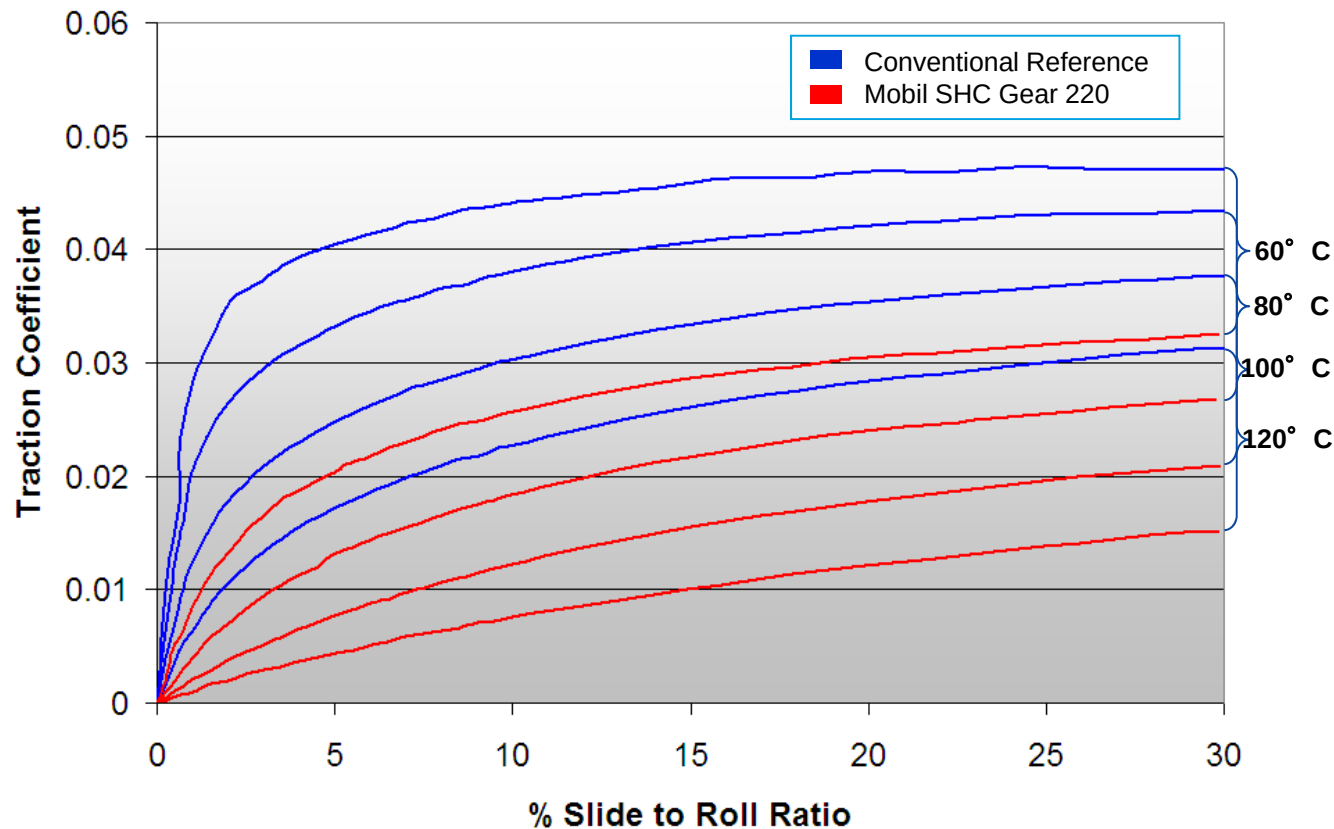
Mini Traction Machine (MTM)



Low Traction Benefit-Mobil SHC Gear 220



- Mobil SHC Gear delivers lower traction than mineral gear oil across a wide temperature range



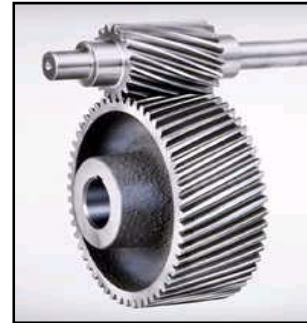
Efficiency and Sliding by Industrial Gear Type



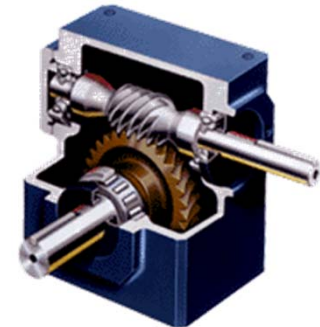
Spur gears



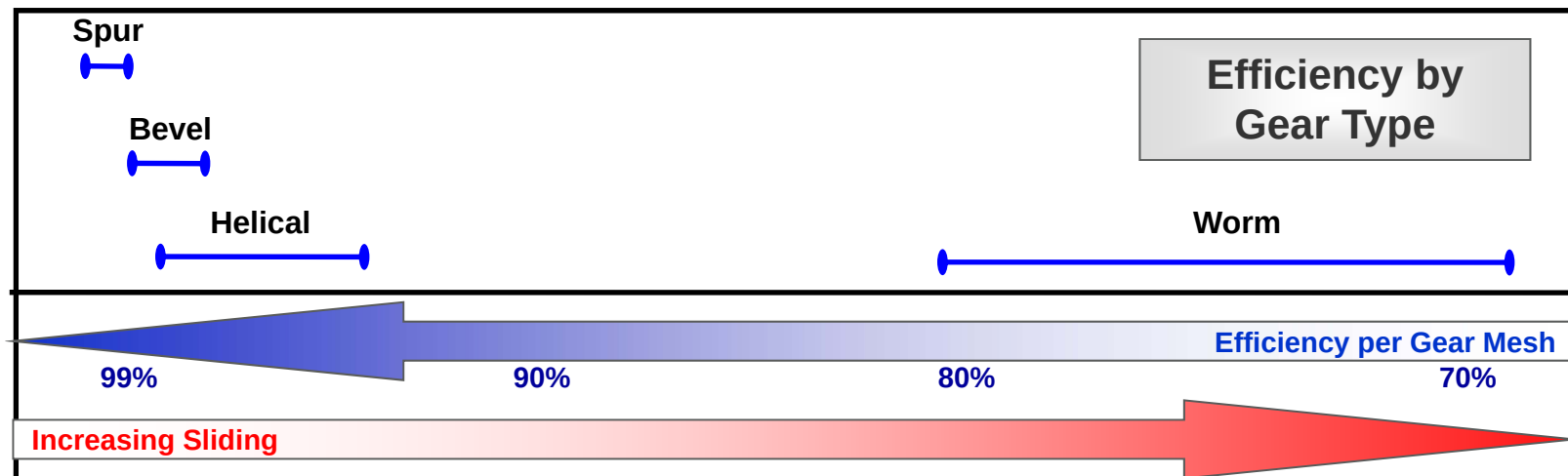
Bevel gears



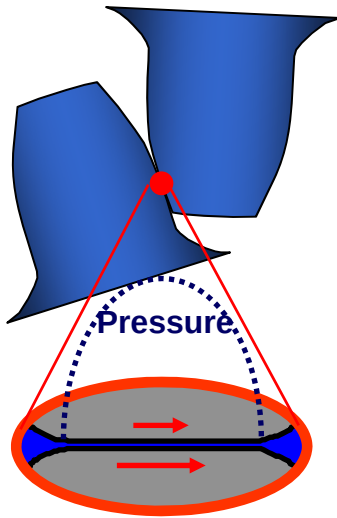
Helical Gears



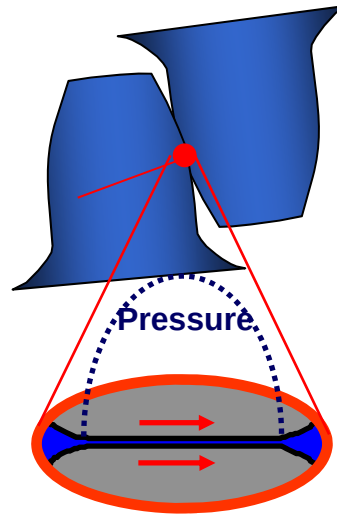
Worm Gears



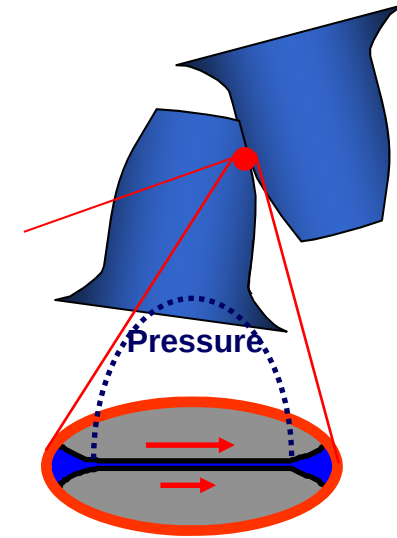
Traction in Machine Elements - Meshing Gear Teeth



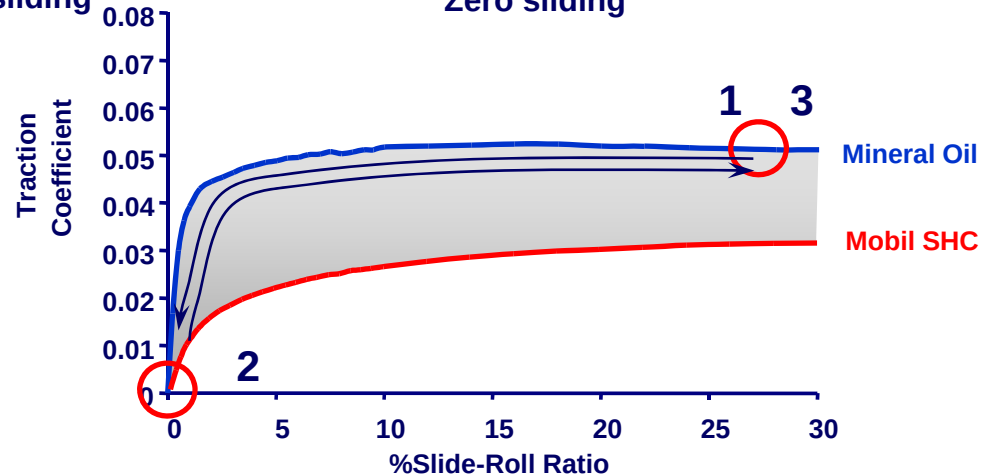
1. Start of meshing cycle
Positive sliding



2. Pitch line
Zero sliding

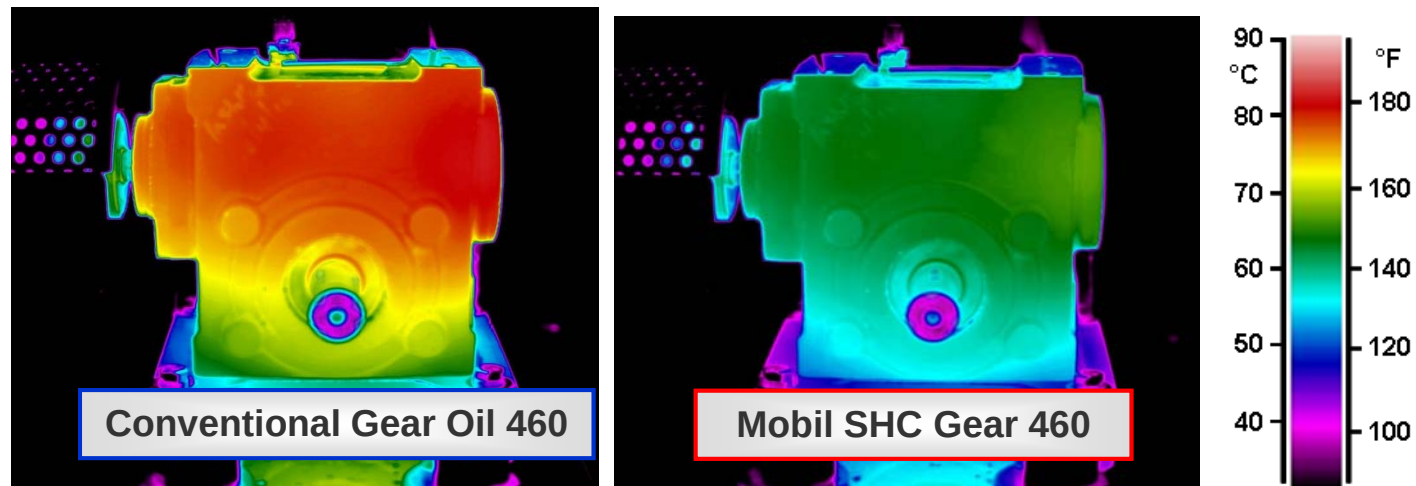


3. End of meshing cycle
Negative sliding



Mobil SHC saves energy over most of the meshing cycle

Testing Confirms Energy Efficiency Benefit Mobil SHC 600 / Mobil SHC Gear



- Mobil SHC Gear oil sump temperature is 16° C / 29° F lower
 - Higher gearbox temperature indicates lower energy efficiency
 - Lower gearbox temperature indicates higher energy efficiency
- Additional benefits of lower operating temperature include
 - Increased equipment life
 - Reduced maintenance cost

Thermographs from controlled testing indicate energy efficiency benefit of Mobil SHC Gear versus conventional gear oil

Energy Efficiency Summary

Mobil SHC 600 / Mobil SHC Gear



- Many lubricated contacts in Industrial equipment operate under EHL conditions
- Losses in EHL contacts depend on fluid traction (internal friction) properties
- Mobil SHC Gear has lower traction than conventional gear oils
- Potential gear oil energy efficiency benefit depends on gear types, number of gear reduction stages, duty cycle, and lubrication conditions

Mobil SHC Gear delivers up to 3.6% energy efficiency* benefit versus conventional gear oil



ExxonMobil

*Energy efficiency relates solely to the fluid performance when compared to conventional (mineral) reference oils of the same viscosity grade. The technology used provides up to 3.6% efficiency compared to the reference when tested in a worm gearbox under controlled conditions. Efficiency improvements will vary based on operating conditions and application.



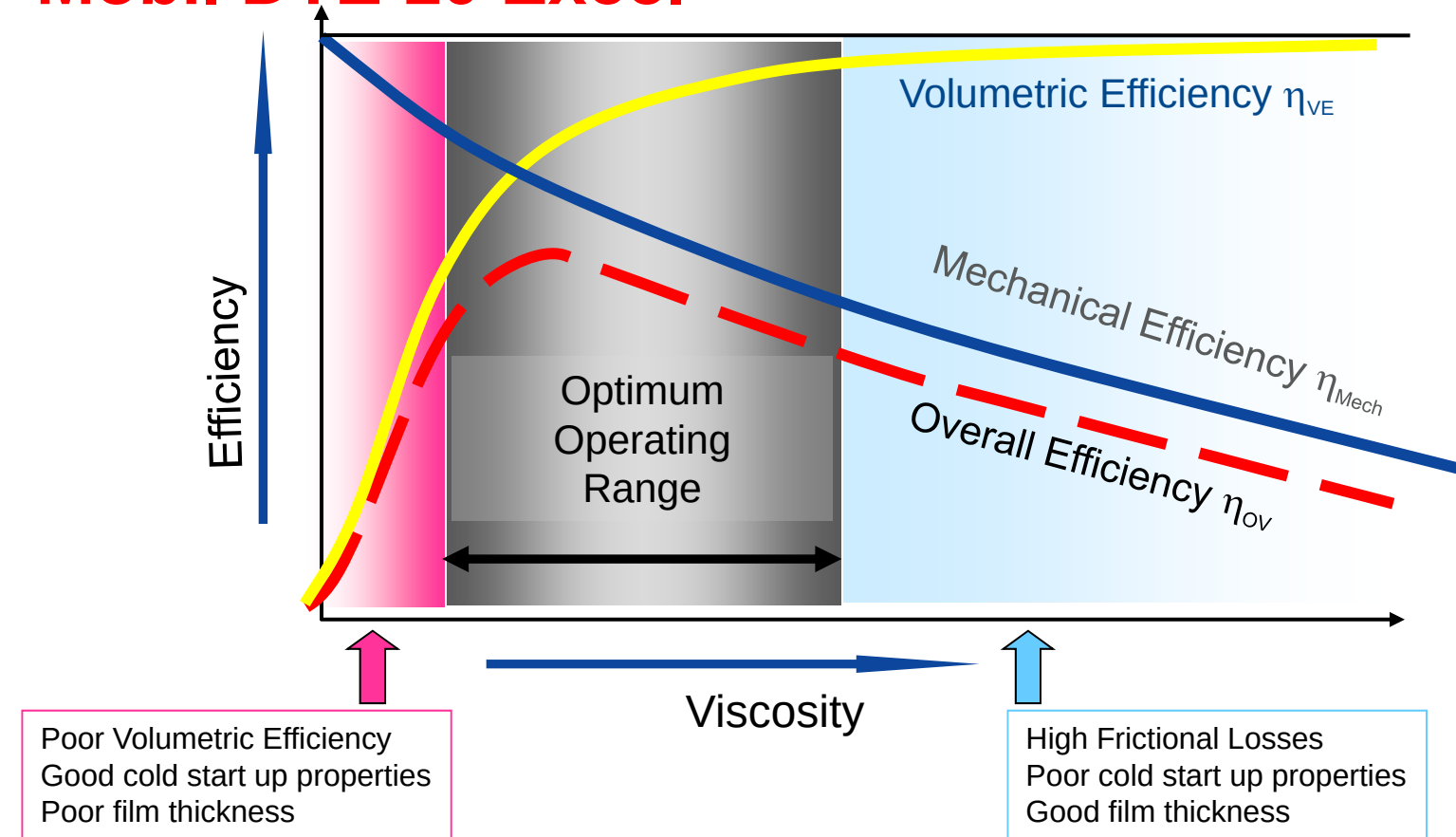
Mobil DTE 10 Excel

**High Viscosity Index and
shear stable hydraulic oils**



Hydraulic Efficiency : Theory

Mobil DTE 10 Excel



- Oil viscosity has a significant impact on hydraulic efficiency
- Overall efficiency is a balance between Mechanical and Volumetric
- Shear Stable High VI fluids enable increased hydraulic efficiency

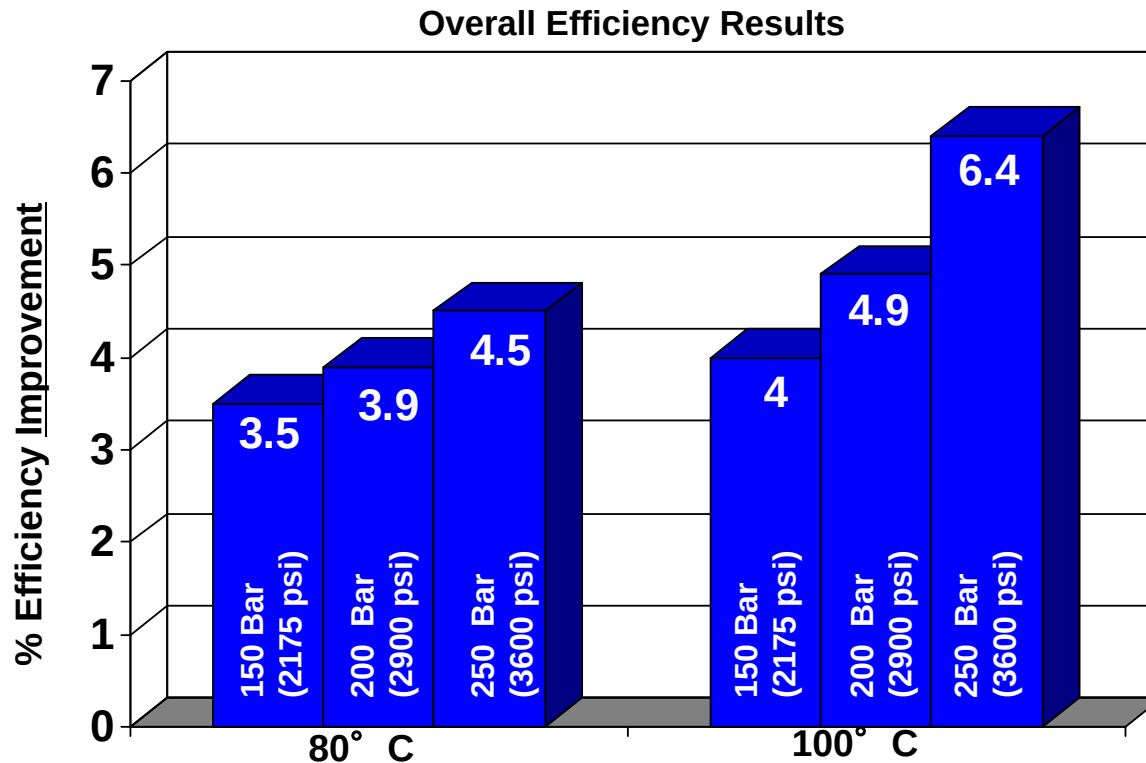
Efficiency Demonstration

Mobil DTE 10 Excel



Hydraulic Efficiency Rig Test – Denison T6C vane pump

- Controlled test to measure overall hydraulic efficiency of high VI fluids
- Efficiency benefits measured relative to ISO 46 100 VI

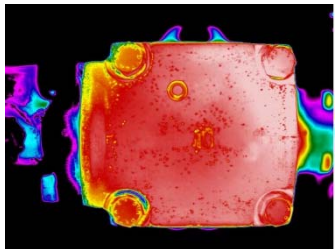


Mobil DTE 10 Excel provides efficiency benefits:

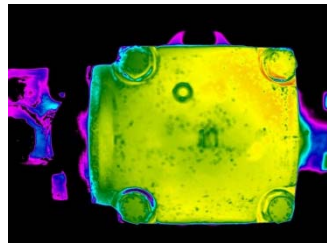
- Up to 6.4% overall hydraulic efficiency benefit versus reference fluids

Test Concept

DTE 10 Excel



Higher Temperature =
Less Efficient Fluid



Lower Temperature =
More Efficient Fluid

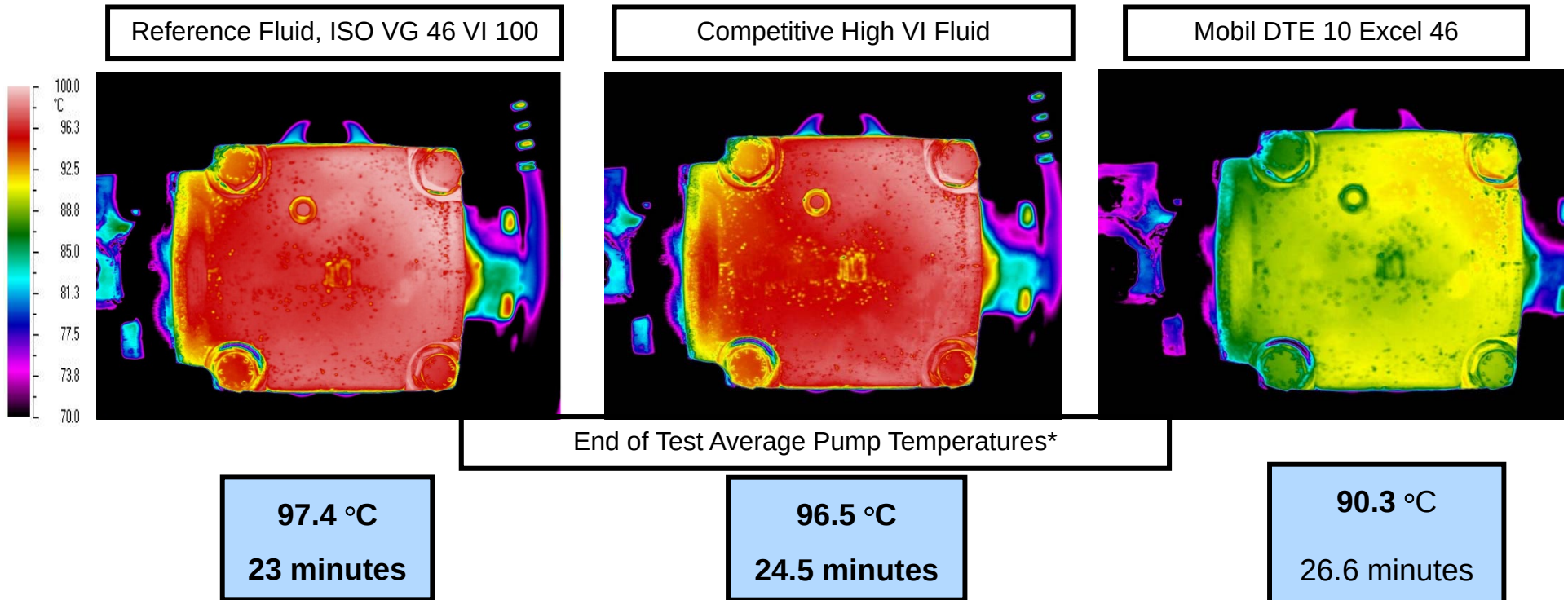
- Increased internal leakage or friction generates more heat across the pump
 - A fluid that enhances volumetric/mechanical efficiency will generate relatively less heat
- Thermal images can compare two fluids and judge the relative efficiency by relative heat generation
- Change in fluid temperature (dT) across the pump further demonstrates relative efficiency

Thermal Imaging Efficiency Demonstration

DTE 10 Excel



Simple Hydraulic Circuit without Heat Exchanger (no cooling)



Mobil DTE 10 Excel Reduced Pump Temperature = Improved Efficiency

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ExxonMobil * Note: Average pump temperature as measured by thermal camera over a consistent defined area of the pump cover plate. End of test times vary based on system heat accumulation.

Mobil SHC Energy Efficiency Concept

- **“Measurement gives access to knowledge”**
(Heike Kamerlingh Onnes, Physics Nobel Prize, 1913)
- ... of Energy Efficiency

