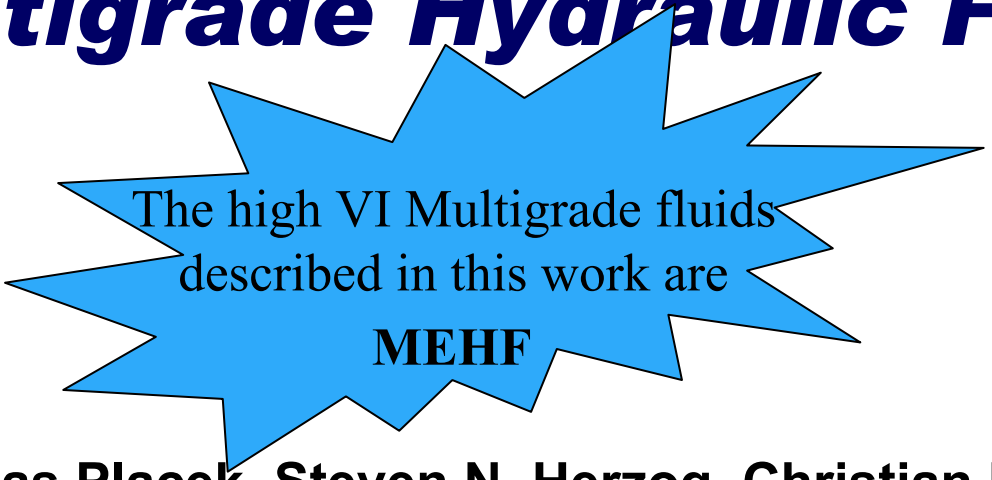
Reducing Energy Consumption with Multigrade Hydraulic Fluids



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Degussa – RohMax Oil Additives

Presentation Overview

- Relationship of Fluid Viscosity to Pump Efficiency
- Fluid Viscosity Grade Selection
- Energy Consumption Models
  - Monograde Fluids (VI = 100)
  - Multigrade or MEHF (high VI oils)
  - Significance of Viscosity Index
- Cost Saving Examples
  - Total Fuel and CO_2 generation Reduction

Multigrade Hydraulic Fluids Can Reduce Energy Consumption !

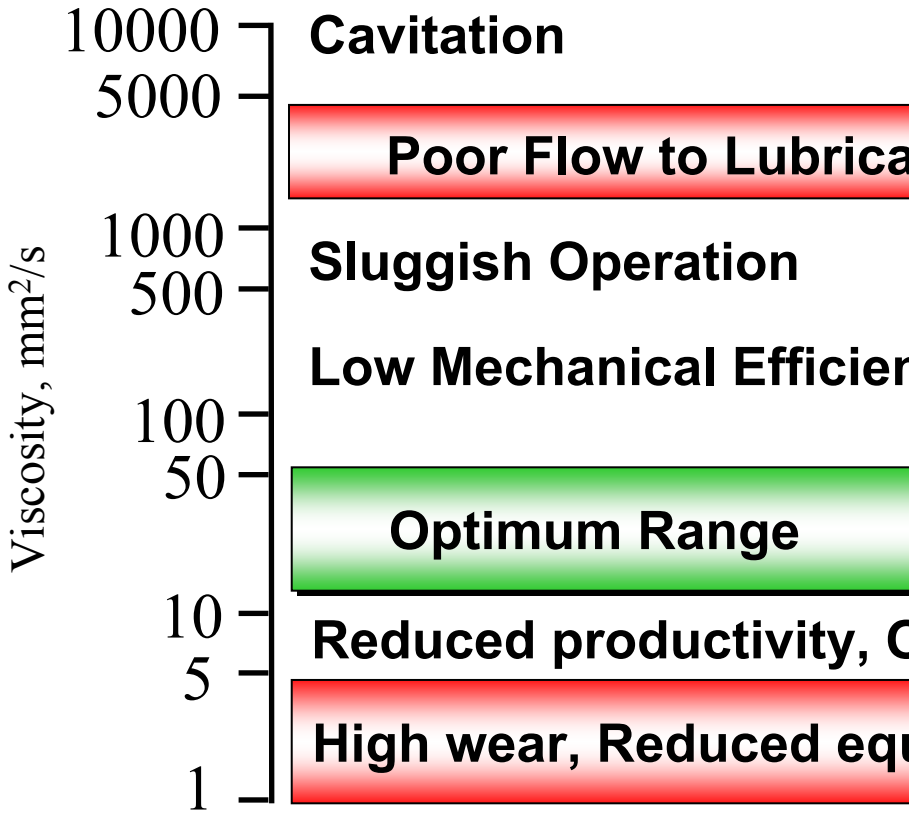
How?

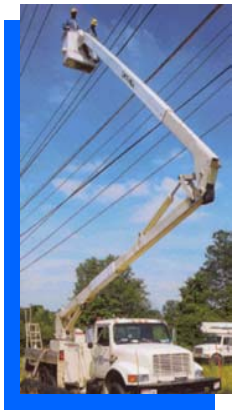
By Increasing and Maximizing Pump Efficiency

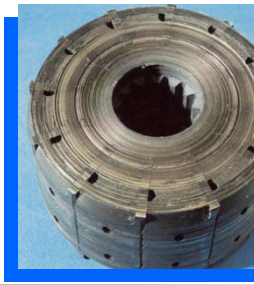
Why?

Optimized Viscosity at Start-up, Normal Operation, and Peak Load Conditions

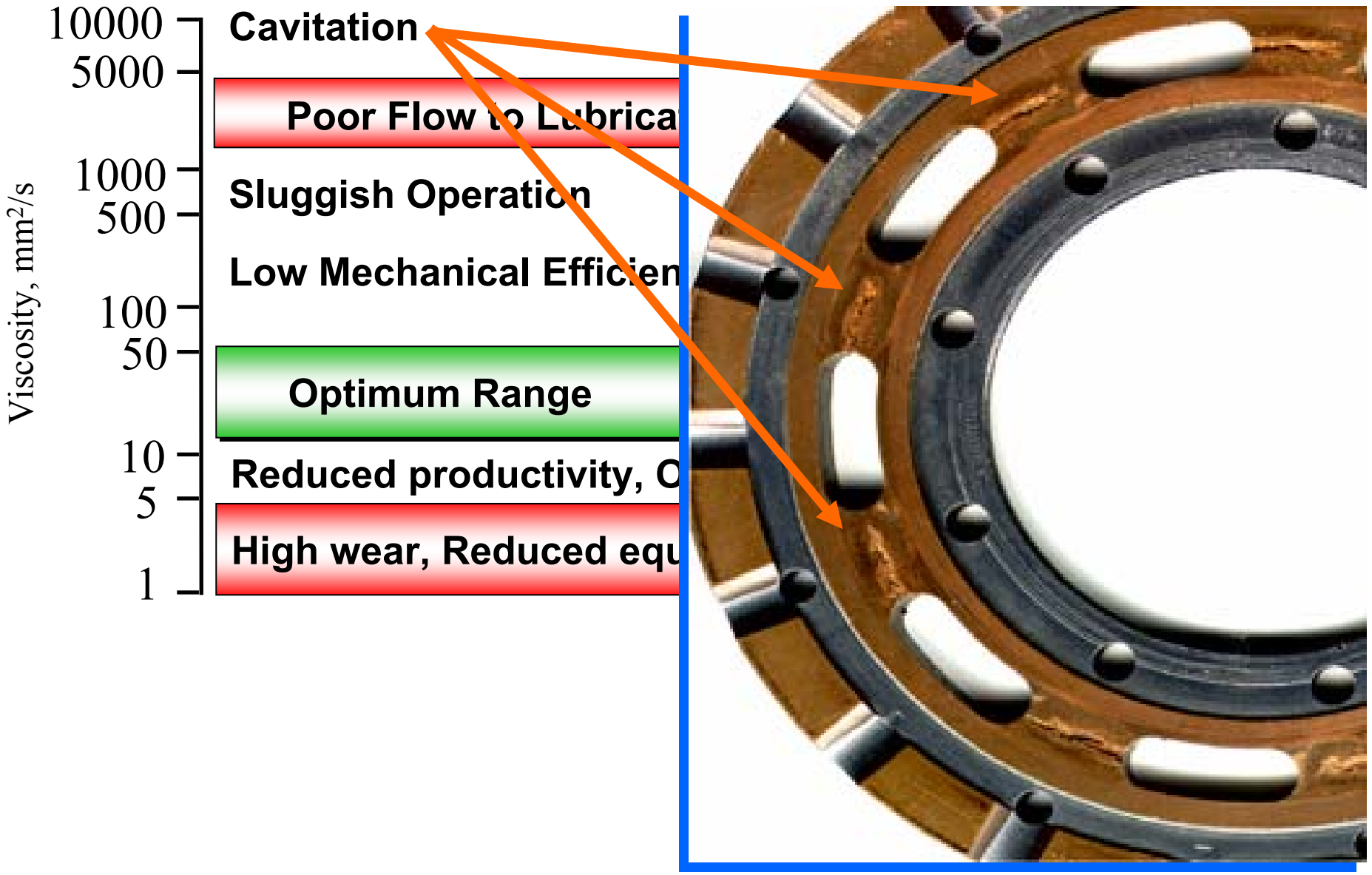
Viscosity Versus Performance



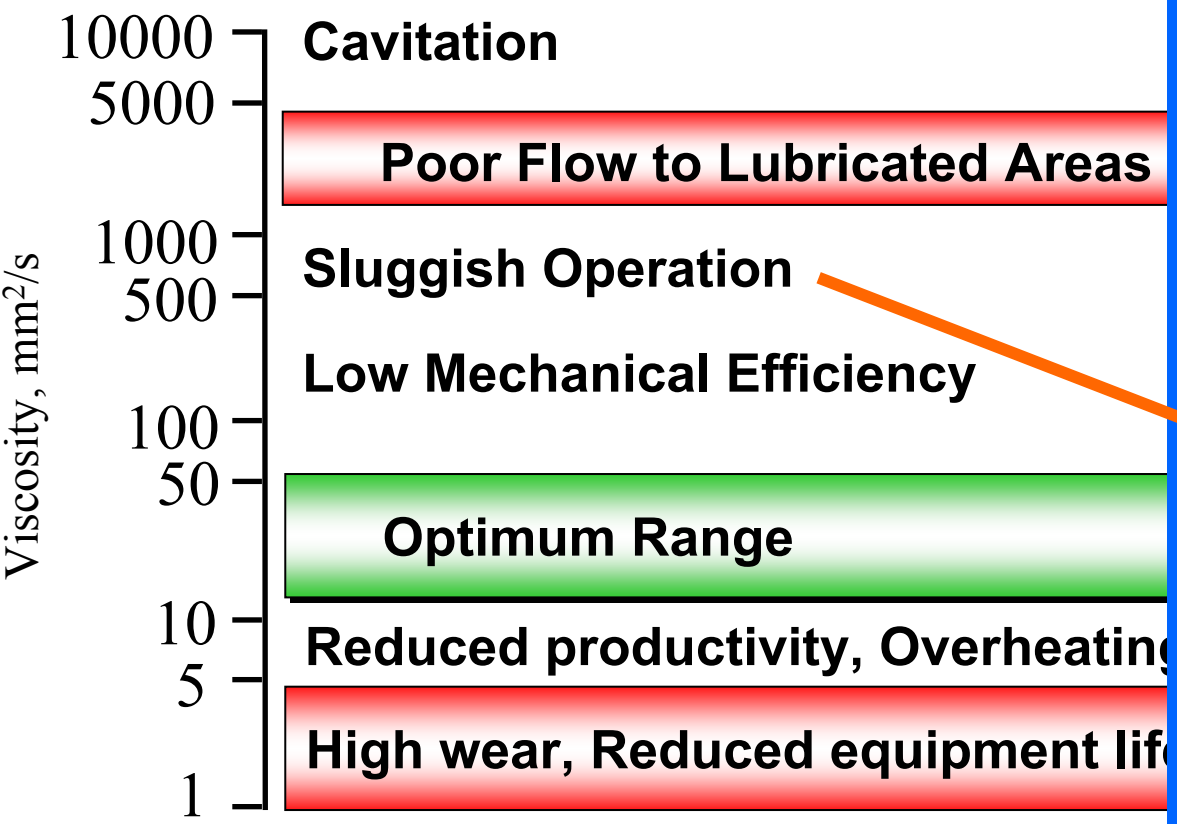




Viscosity Versus Performance



Viscosity Versus Performance



Viscosity Versus Performance

Viscosity, mm^2/s

10000
5000
1000
500
100
50
10
5
1

Cavitation

Poor Flow to Lubricated Areas

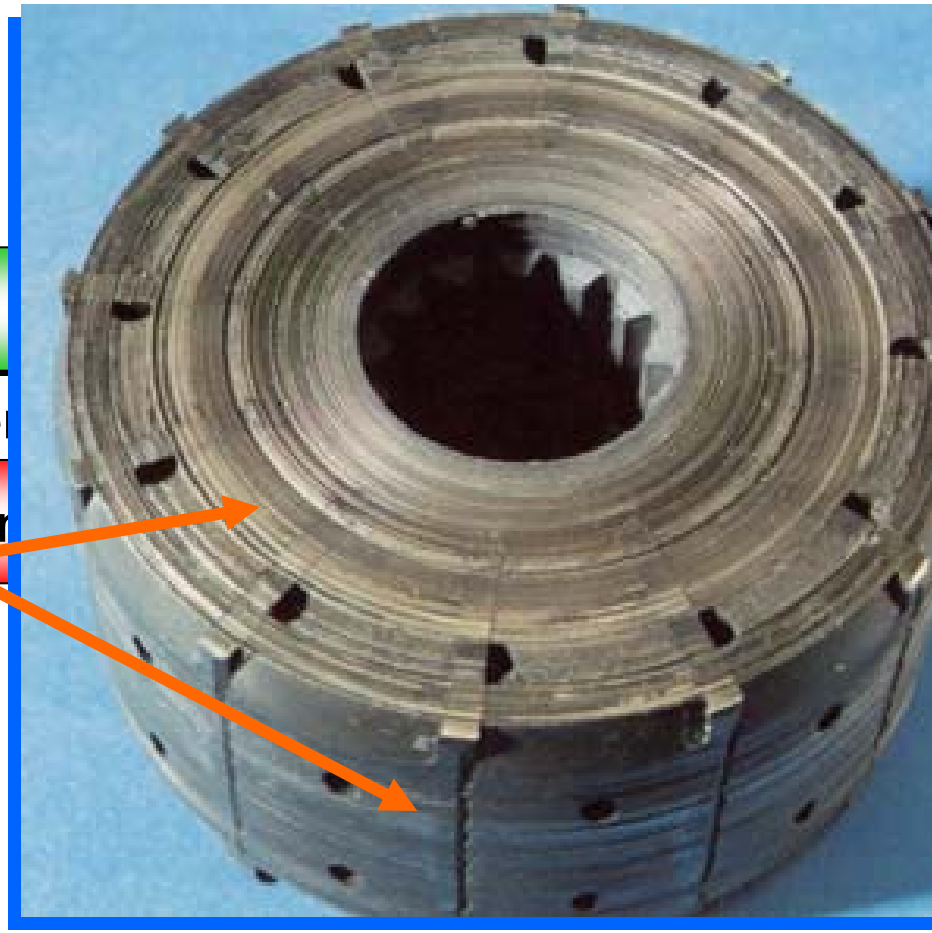
Sluggish Operation

Low Mechanical Efficiency

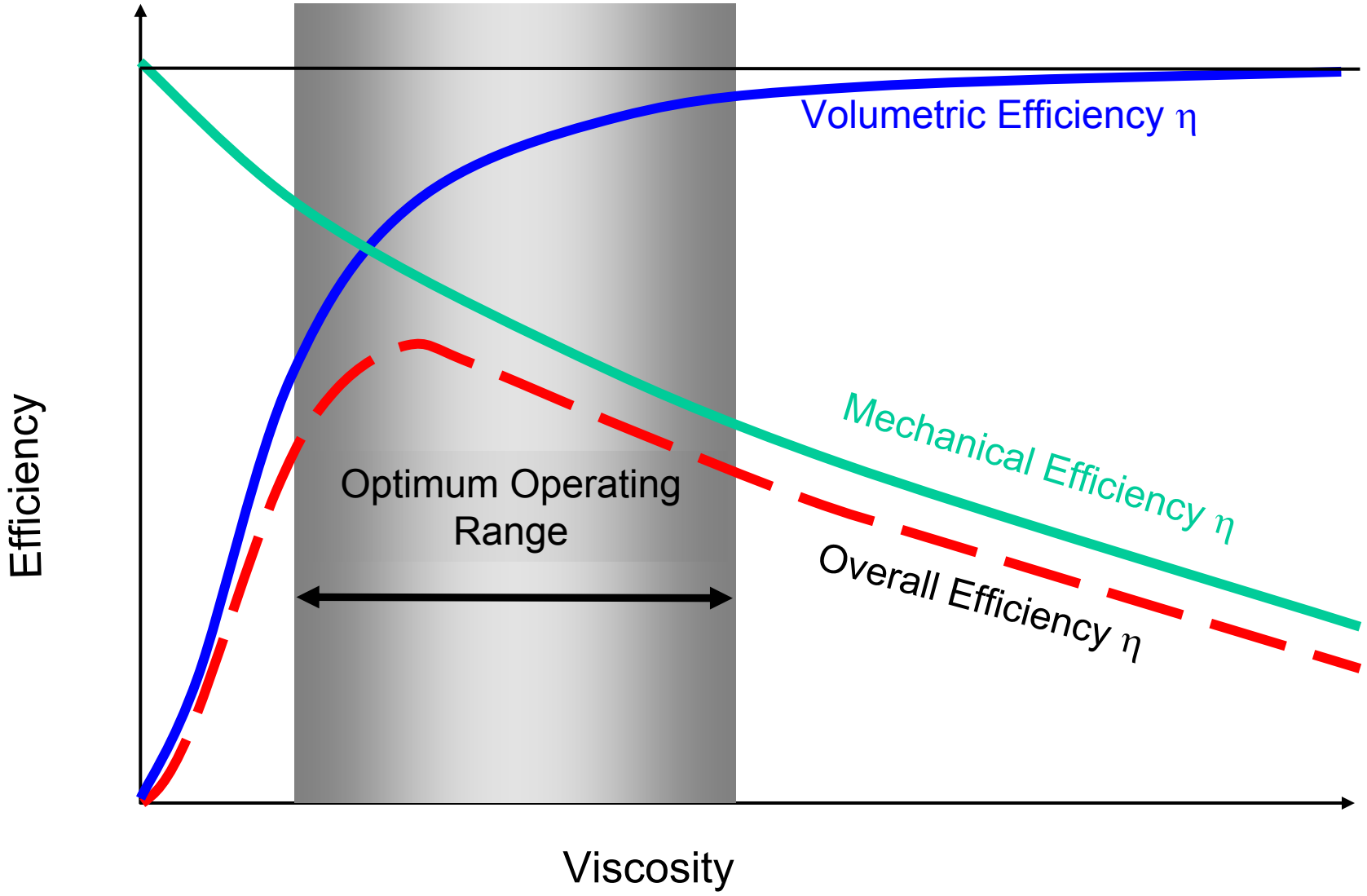
Optimum Range

Reduced productivity, Ove

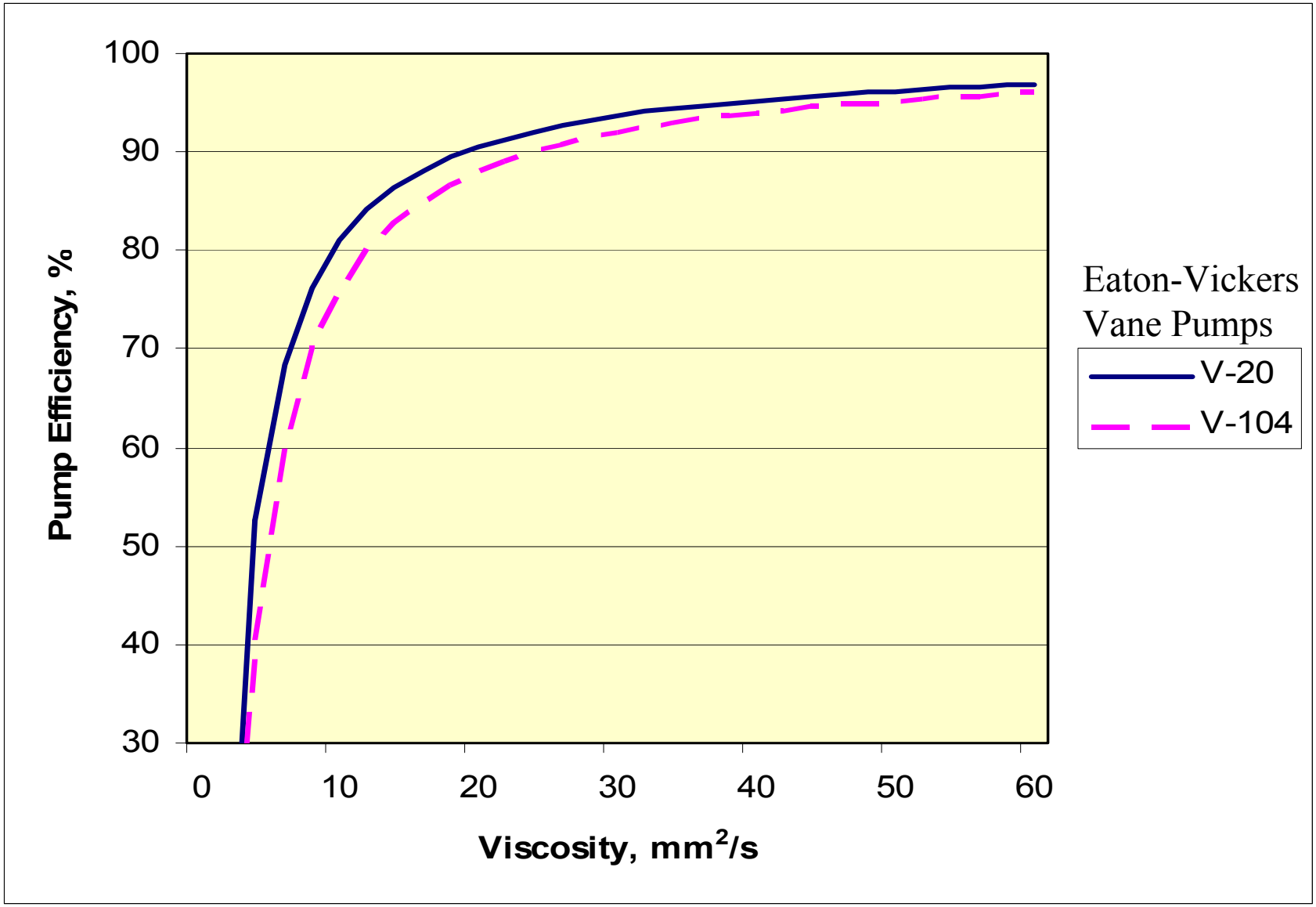
High wear, Reduced equipr



Effects of Viscosity on System Efficiency



Volumetric Efficiency Losses



What is the Best Fluid for the Operation?

Highest Performance? Lowest Cost? Both?

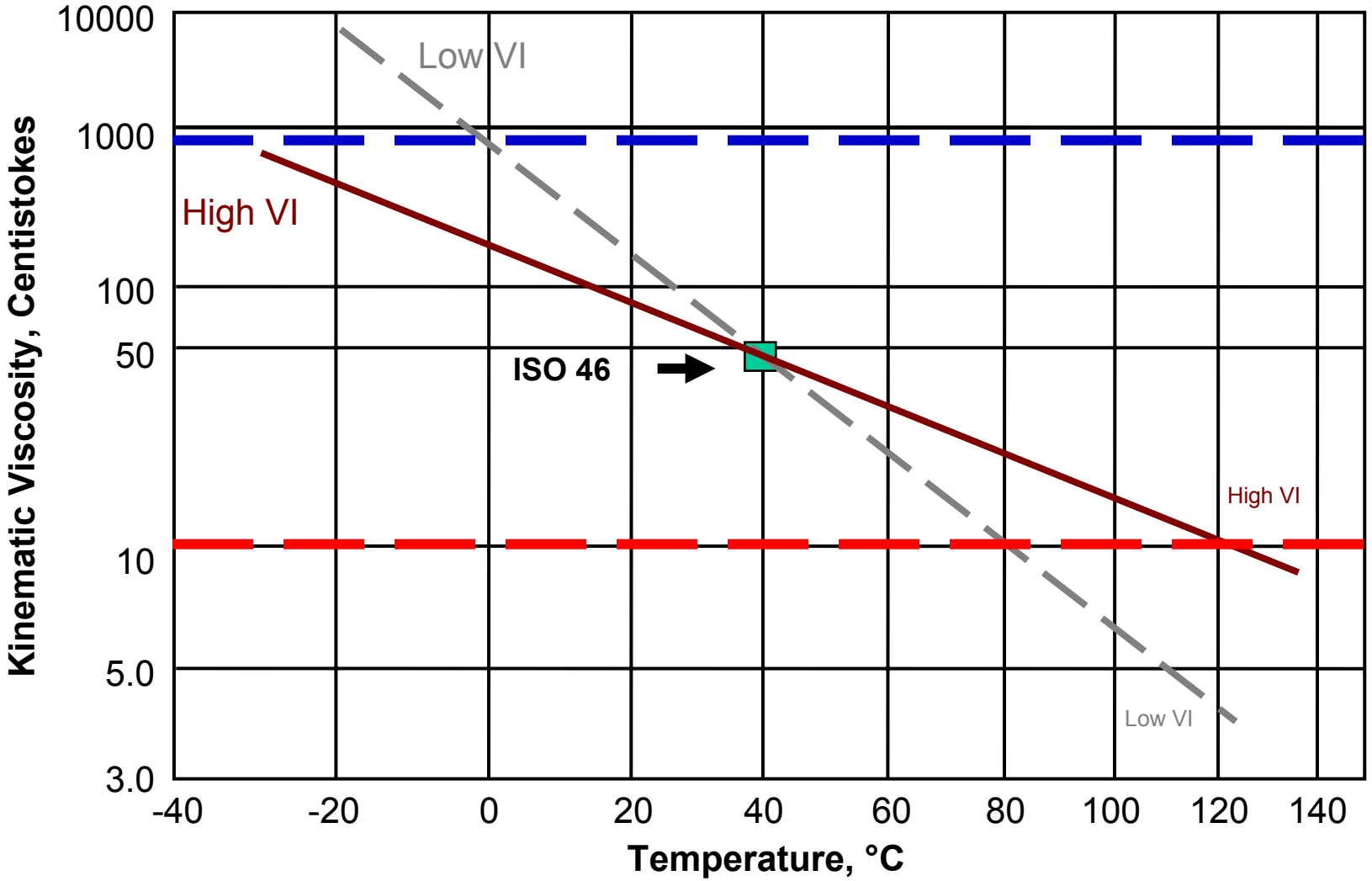
- OEM's and Equipment Builders give Viscosity Recommendations for Individual Pumps and Systems
- Similar systems can run under different Loads, Speeds, Pressures and Temperatures
- A typical operation has Multiple Pumps and Systems

Hydraulic Fluid Viscosity Grade Options

- Monograde ISO 32, 46, 68
  - VI ~ 100
- Multigrade ISO 32, 46, 68
  - VI ranging from 125 to 300

High VI Expands the fluid Temperature Operating Window

Two Oils Meeting ISO 46 Viscosity Requirements

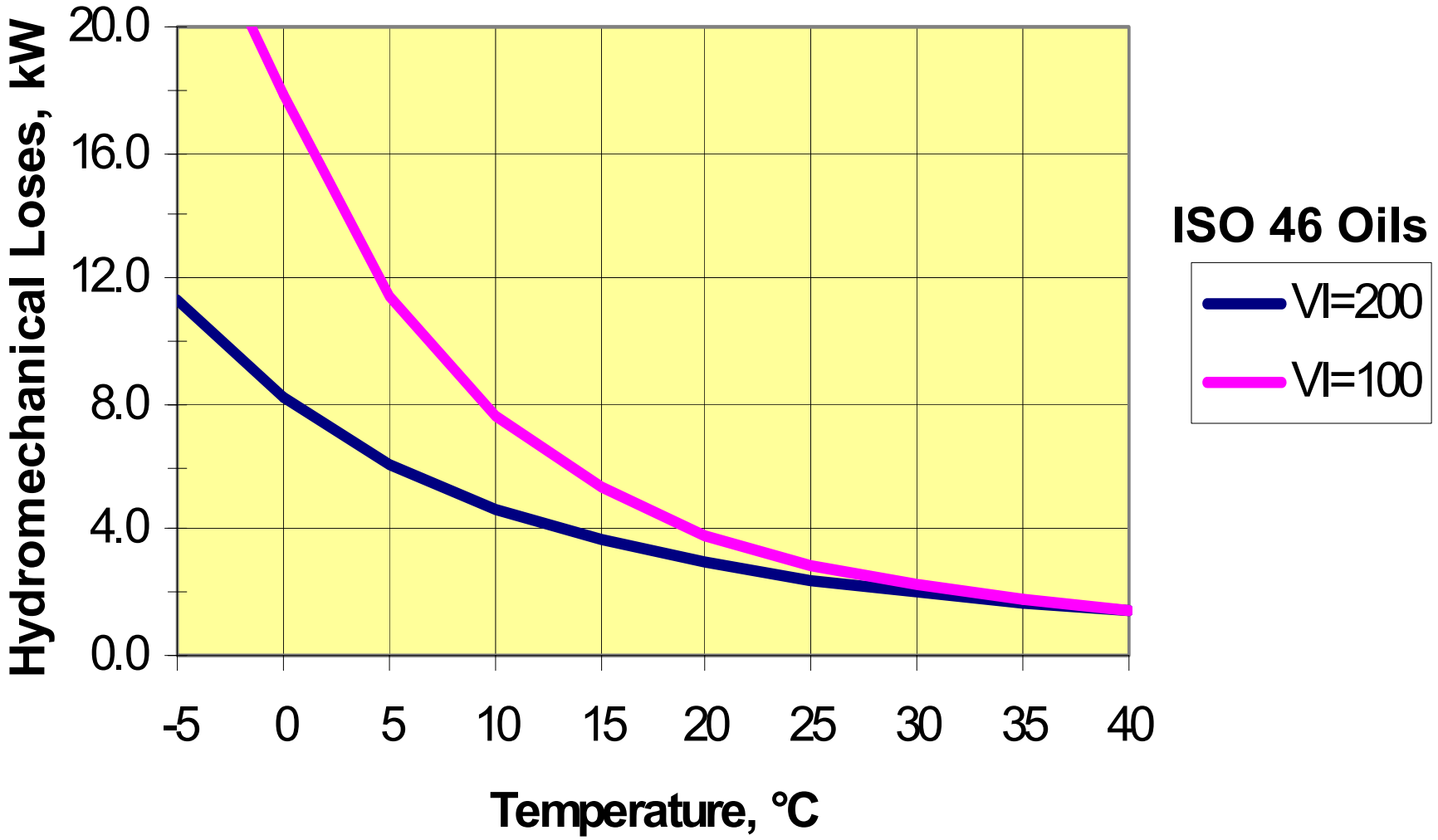


Hydraulic Fluid Properties

	ISO Grade					
Property	**VG 32**		**VG 46**		**VG 68**	
VI	**100**	**200**	**100**	**200**	**100**	**200**
KV at 40 ºC, mm^2/s	**32.0**	**32.0**	**46.0**	**46.0**	**68.0**	**68.0**
KV at 100 ºC, mm^2/s	**5.36**	**7.16**	**6.72**	**9.53**	**8.73**	**13.06**
Temperature for 860 mm^2/s, ºC	**-7**	**-19**	**-2**	**-14**	**4**	**-8**
VI after 40 minute Sonic Shear	**100**	**184**	**100**	**187**	**100**	**188**
NFPA T2/13.13.2002 Grade	**L32-32**	**L22-46**	**L46-46**	**L32-68**	**L68-68**	**L32-100**

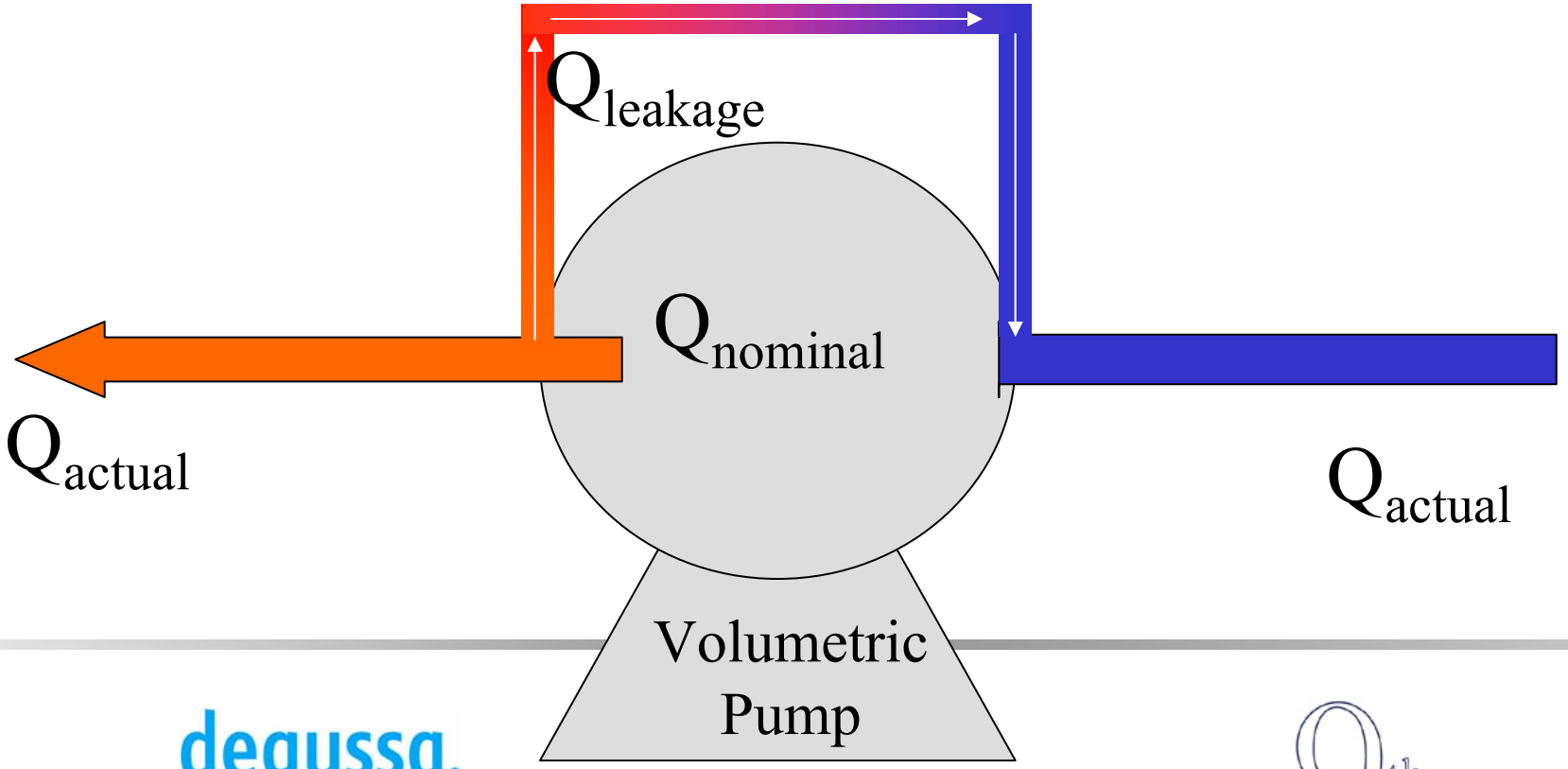
Hydromechanical Energy Losses

(in a Vane Pump)



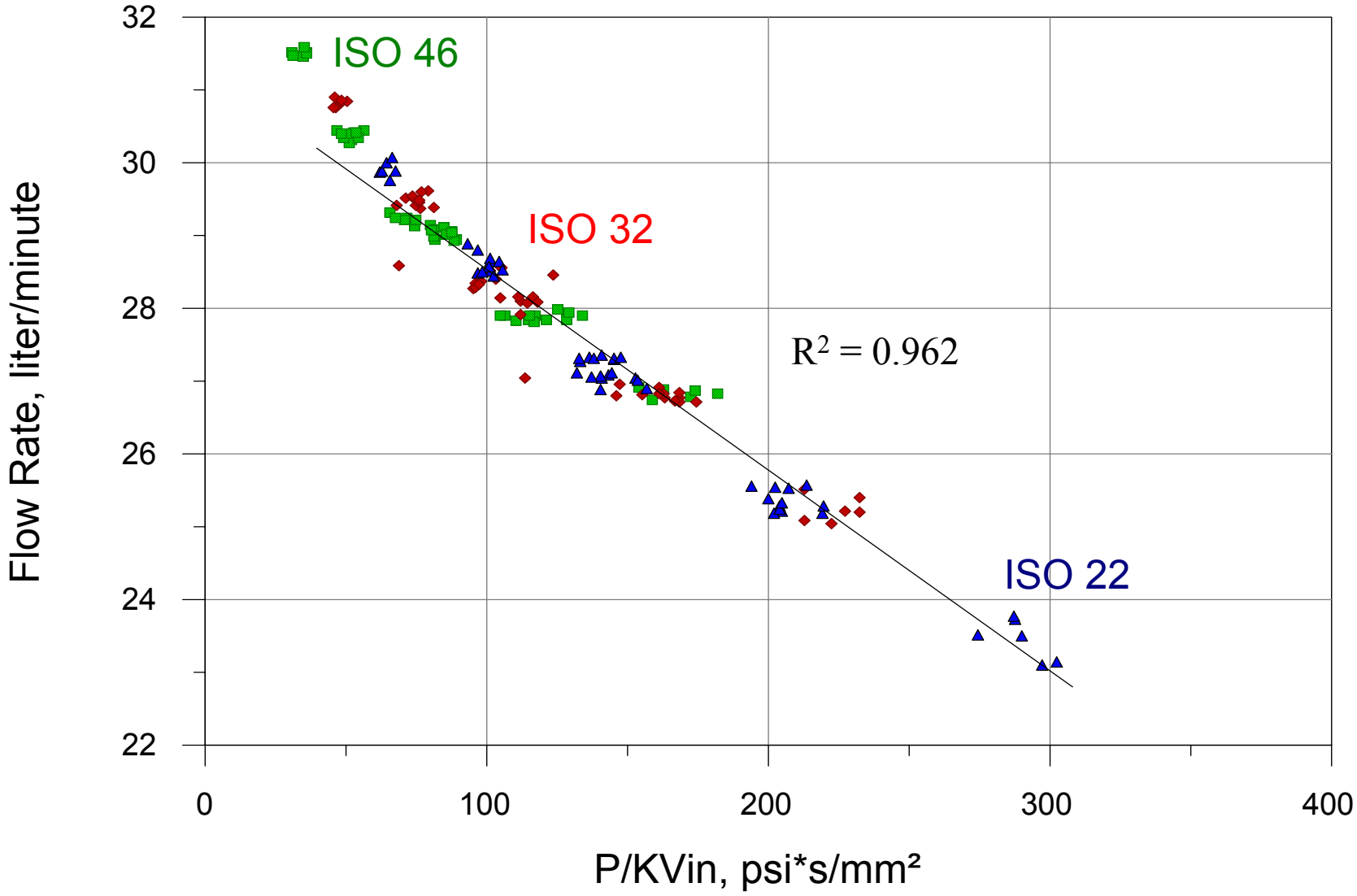
Actual vs. Nominal Flow Rate

$$Q_a = Q_n - Q_l$$



Pump Flow Rate vs. Viscosity and Pressure

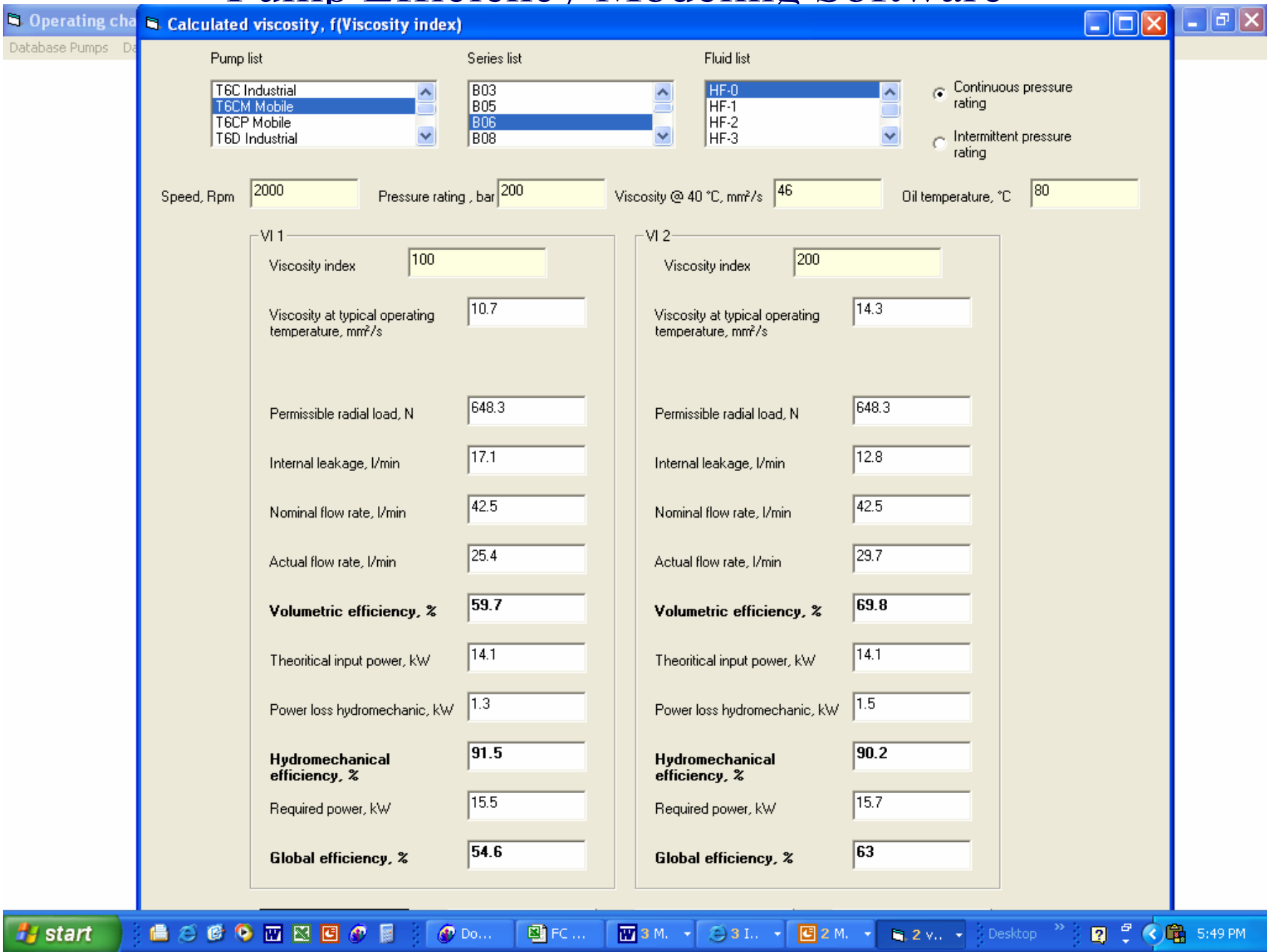
(in a Vane Pump)



Development of Efficiency Models

- Pump OEM's publish performance information
  - Nominal flowrate
  - Actual flowrate as a function of:
    - Speed
    - Pressure
    - Temperature
- RohMax has Evaluated Fluid VI Effects
  - Pump rig testing
  - Modeling

Pump Efficiency Modeling Software



Energy Savings-
Multigrade vs. Monograde Hydraulic Fluids

- Models developed to describe mobile vane pumps from a global OEM
- Performance were compared under the following "Typical" Conditions:
  - Pressure: 200 Bars
  - Speed: 2000 rpm
  - Temperature: 80 °C and 100 °C

Energy Savings- Multigrade vs. Monograde Hydraulic Fluids

Mobile Vane Pumps at 200 bar, 2000 rpm, **80°C**

		Energy Savings, %		
Cartridge Size	Nominal Flow Rate, liters/minute	ISO 32	ISO 46	ISO 68
A	**43**	**20.0%**	**14.6%**	**9.0%**
B	**68**	**8.3%**	**6.8%**	**4.7%**
C	**92**	**5.7%**	**4.6%**	**3.2%**
D	**140**	**3.3%**	**2.7%**	**2.0%**

$$Energy_{(VI=100)}/Energy_{(VI=200)} = Power_{(VI=100)}*Qa_{(VI=200)}/[Power_{(VI=200)}*Qa_{(VI=100)}]$$

Energy Savings-
Multigrade vs. Monograde Hydraulic Fluids

Mobile Vane Pumps at 200 bar, 2000 rpm, **100°C**

		Energy Savings, %		
Cartridge Size	Nominal Flow Rate, liters/minute	ISO 32	ISO 46	ISO 68
A	**43**	*	*	**27.9%**
B	**68**	**22.0%**	**17.4%**	**12.9%**
C	**92**	**12.8%**	**11.0%**	**8.5%**
D	**140**	**6.9%**	**6.2%**	**5.0%**

$$Energy_{(VI=100)}/Energy_{(VI=200)} = Power_{(VI=100)}*Qa_{(VI=200)}/[Power_{(VI=200)}*Qa_{(VI=100)}]$$

Cost Saving Examples

Estimated Fuel and Cost Savings were calculated according to the following formula:

1. The Energy requirement to run the pump at a desired speed and output is measured.
2. Typical diesel engine fuel consumption rates are known.

typical, state of the art engine data			
diesel fuel	nominal	240	g/kWh
consumption	best	205	g/kWh
	average	220	g/kWh

3. Hours of pump or equipment operation are known, or are suggested in the example.
4. Typical oil temperatures are estimated to be ~80°C.
5. Cost of diesel fuel in selected country or region is known.

Fuel Savings = Pump Energy Requirement (kW) *

Diesel Fuel Consumption Rate (0.22 kg/kWh) *

Density of Diesel Fuel (1.19 l/kg) *

Hours of Operation = Liters of diesel fuel

Cost Savings = Fuel Savings (liters) * Cost of Diesel Fuel (per liter)

Energy Savings- Example 1
ISO 46 Multigrade vs. Monograde HF

Single Mobile Vane Pump at 200 bar, 2000 rpm, **80°C**

Pump	A	B	C	D
kW	15.5	24.0	31.9	48.1
Liters of Diesel Used	8,116	12,566	16,703	25,185
Liters of Diesel Saved	1,186	849	761	688
Annual ¥ Saved (Japan)	94,889	67,933	60,910	55,071
Annual $ Saved (US Dollars)	791	566	508	459

Assumptions: 8 Hours/day, 250 Days/year, Diesel Fuel in Japan @ 80¥/liter

Energy Savings- Example 2
ISO 46 Multigrade vs. Monograde HF

Construction Equipment Fleet- 100 Units
200 Mobile Vane Pumps at 200 bar, 2000 rpm, **80°C**

Pump	A	B	C	D
kW	15.5	24.0	31.9	48.1
Liters of Diesel Saved	142,334	101,900	91,365	82,606
Annual M ¥ Saved (Japan)	11.4	8.2	7.3	6.6
Annual K$ Saved (US Dollars)	91.1	65.2	58.5	52.9

Assumptions: 8 Hours/day, 150 Days/year, Diesel Fuel in Japan @ 80¥/liter

Energy Savings- Example 2
ISO 46 Multigrade vs. Monograde HF

Heavy Duty Mobile Construction Equipment in Japan, Bulldozers, Excavators, Wheel Loaders currently in service 1.2 M Units with Pumps at 200 bar, 2000 rpm, **80°C**

Pump	A	B	C	D
kW	15.5	24.0	31.9	48.1
M Liters of Diesel Saved	996	713	640	578
Annual B ¥ Saved (Japan)	80	57	51	46
Annual M$ Saved (US Dollars)	638	457	409	370

Assumptions: 4 Hours/day, 175 Days/year, Diesel Fuel in Japan @ 80¥/liter

Summary of Energy and Cost Savings Examples in Japan

- Single Vane Pump, ¥ 72K/yr $ 600/yr
- Mobile Equipment Fleet, ¥ 9M/yr $ 75K/yr
- Heavy Duty Earth Movers, in Service in Japan ¥ 50B/yr $ 425M/yr

Energy Savings- Example 1
ISO 46 Multigrade vs. Monograde HF

Single Mobile Vane Pump at 200 bar, 2000 rpm, **80°C**

Pump	A	B	C	D
kW	15.5	24.0	31.9	48.1
Liters of Diesel Used	8,116	12,566	16,703	25,185
Liters of Diesel Saved	1,186	849	761	688
Annual € Saved (Germany)	1,008	722	647	585

Assumptions: 8 Hours/day, 250 Days/year, Diesel Fuel in Germany @ 0.85€/liter

Energy Savings- Example 2
ISO 46 Multigrade vs. Monograde HF

Construction Equipment Fleet- 100 Units
200 Mobile Vane Pumps at 200 bar, 2000 rpm, **80°C**

Pump	A	B	C	D
kW	15.5	24.0	31.9	48.1
Liters of Diesel Saved	142,334	101,900	91,365	82,606
Annual T € Saved (Germany)	121	86.6	77.7	70.2

Assumptions: 8 Hours/day, 150 Days/year, Diesel Fuel in Germany @ 0.85€/liter

Summary of Energy and Cost Savings Examples in Europe

- Single Vane Pump,
- Mobile Equipment Fleet,

Energy Savings- Example 1
ISO 46 Multigrade vs. Monograde HF

Single Mobile Vane Pump at 200 bar, 2000 rpm, **80°C**

Pump	A	B	C	D
kW	15.5	24.0	31.9	48.1
Liters of Diesel Used	8,116	12,566	16,703	25,185
Liters of Diesel Saved	1,186	849	761	688
Annual CAD Saved (0.65 CAD/l)	771	552	495	447
Annual CAD Saved (0.80 CAD/l)	949	679	609	551

Assumptions: 8 Hours/day, 250 Days/year, Diesel Fuel in Canada @ 0.65- 0.80 CAD/lite

Energy Savings- Example 2
ISO 46 Multigrade vs. Monograde HF

Construction Equipment Fleet- 100 Units
200 Mobile Vane Pumps at 200 bar, 2000 rpm, **80°C**

Pump	A	B	C	D
kW	15.5	24.0	31.9	48.1
Liters of Diesel Saved	142,334	101,900	91,365	82,606
Annual T CAD Saved (0.65 CAD/l)	92.5	66.2	59.4	53.7
Annual T CAD Saved (0.80 CAD/l)	113.9	81.5	73.1	66.1

Assumptions: 8 Hours/day, 150 Days/year, Diesel Fuel in Canada @ 0.65 - 0.80 CAD/lite

Summary of Energy and Cost Savings Examples in Canada

- Single Vane Pump, **579 - 700 CAD/yr**
- Mobile Equipment Fleet, **68K - 84K CAD/yr**

Energy Savings- Example 1
ISO 46 Multigrade vs. Monograde HF

Single Mobile Vane Pump at 200 bar, 2000 rpm, **80°C**

Pump	A	B	C	D
kW	15.5	24.0	31.9	48.1
Gallons of Diesel Used	2,141	3,316	4,407	6,645
Gallons of Diesel Saved	313	224	201	182
Annual $ Saved (USA)	532	381	342	309

Assumptions: 8 Hours/day, 250 Days/year, Diesel Fuel in USA @ $1.70/gallon

Energy Savings- Example 2
ISO 46 Multigrade vs. Monograde HF

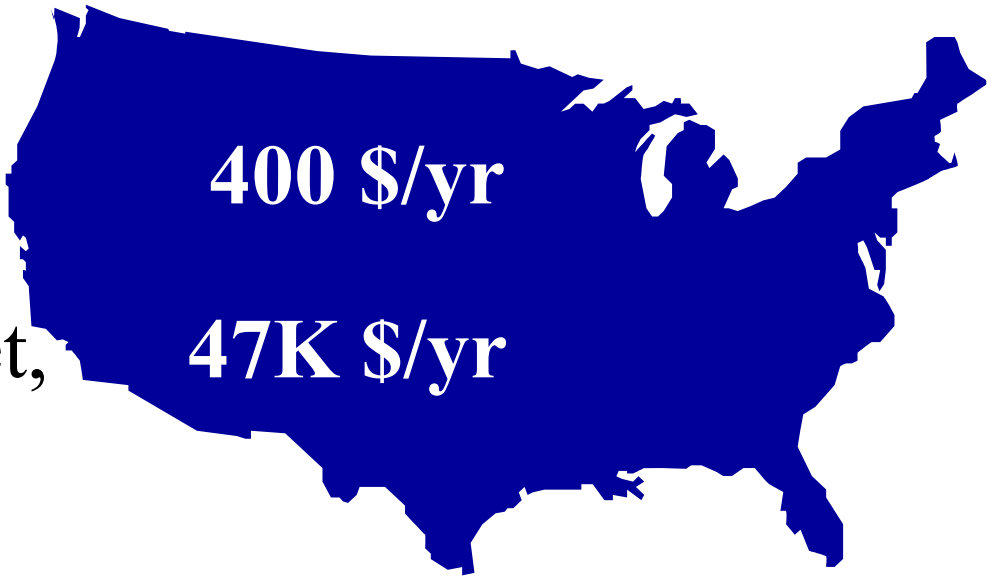
Construction Equipment Fleet- 100 Units
200 Mobile Vane Pumps at 200 bar, 2000 rpm, **80°C**

Pump	A	B	C	D
kW	15.5	24.0	31.9	48.1
Gallon of Diesel Saved	37,557	26,888	24,108	21,797
Annual K $ Saved (USA)	63.8	45.7	41.0	37.1

Assumptions: 8 Hours/day, 150 Days/year, Diesel Fuel in USA @ $1.70/gallon

Summary of Energy and Cost Savings Examples in USA

- Single Vane Pump,
- Mobile Equipment Fleet,



Conclusions

- MEHF's Save Energy
  - At cold start-up
  - At normal operating temperatures
- Reduced Fuel Consumption means
  Reduced Emissions !
- Fast pay-back on higher fluid costs