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Maximum Efficiency Hydraulic Fluids

M.E.H.F

Advantages at Low Temperature Operation

November 3, 2004

RohMax OIL ADDITIVES

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Major Viscosity Classifications for Hydraulic Oils

Several classifications or specifications are intended to provide a definition of the oil viscosity under different temperature conditions

- ISO 3448 (ASTM D 2422) - ***ISO VG Classification***
- ASTM D 6080-97 - ***Fresh & Sheared Oil Viscosities***
- NFPA T2.13.13-2002 - ***Viscosity Grade Selection Criteria***
- Swedish Standard SS 15 54 34 - ***Full Formulation Specification***
- Denison HF-O ***- Fresh & Sheared Oil Viscosities***

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ISO 3448 Viscosity Grades

ISO VG	Kinematic Viscosity @ 40 °C, mm²/s		
	Mid-Point	Minimum	Maximum
10	10.0	9.0	11.0
15	15.0	13.5	16.5
22	22.0	19.8	24.2
32	32.0	28.8	35.2
46	46.0	41.4	50.6
68	68.0	61.2	74.8
100	100.0	90.0	110.0
150	150.0	135.0	165.0

Grades are defined by a range of Kinematic Viscosity @ 40 °C

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Deficiencies of ISO 3448 Classification

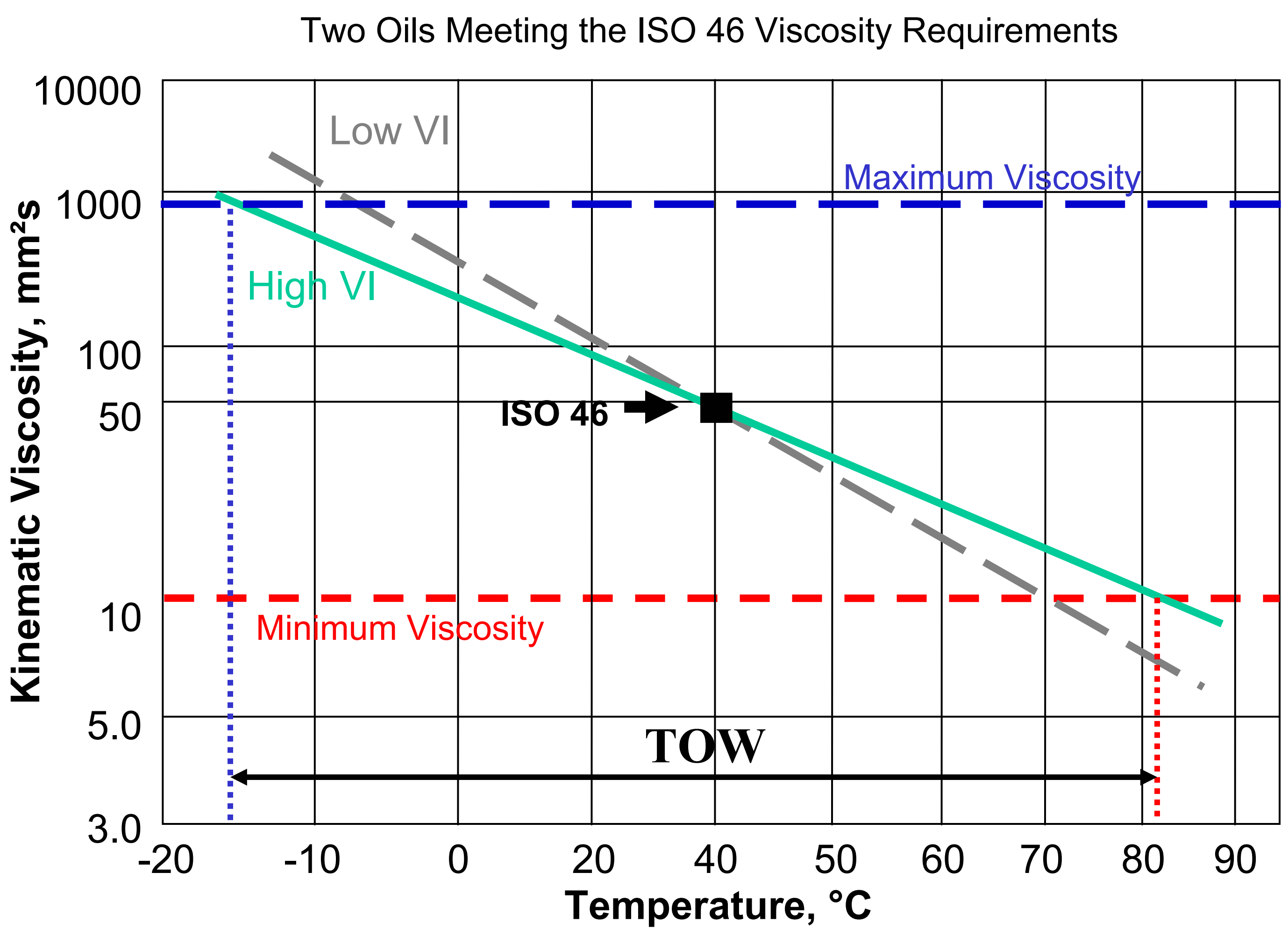
- Information on viscosity is given at only one temperature (40 °C)
  - Provides no information on the oil viscosity
    - At high temperature (> 40 °C)
    - At low temperature (< 40 °C)

- Does not address used oil viscosity
  - Does not include any shear stability measurements

- ISO viscosity grades are not continuous

- ASTM D 6080 was designed to alleviate these shortfalls creating essentials

Effect of VI on the Oil Viscosity Temperature Operating Window



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Designation of Fluids According to ASTM D 6080

ISO VG xx

Lyy-zz (VI)

- **xx** is the fresh oil viscosity grade as per ISO 3448
- **Lyy** is the low temperature grade based on the temperature at which the fresh oil viscosity reaches 750 mPa.s
- **zz** is the viscosity at 40 ° C after shearing in ASTM D 5621 (Sonic 40’)
- **VI** is the viscosity index as per D 2270 after shearing in ASTM D 5621

Example: ISO VG 32
L22-30 (150)

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Definition of Low Temperature Viscosity Grades in ASTM D 6080

Low Temp. Viscosity Grade	Temperature, °C for Brookfield Viscosity of 750 mPa.s		
L10	-33	to	-41
L15	-23	to	-32
L22	-15	to	-22
L32	-8	to	-14
L46	-2	to	-7
L68	+4	to	-1
L100	+10	to	+5
L150	+16	to	+11

750 mPa.s corresponds to about 860 mm^2/s or 4000 SUS

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Deficiencies of ASTM D6080

- Complex system, not fully utilized in the market place
  - Difficult to market oils using this standard
    - May offer more information than customers are requesting
    - Sales force requires training
    - Need to re-label current high VI oils

- Does not provides direct information on the viscosity at high temperature

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Viscosity Selection Criteria
NFPA Recommended Practice T2.13.13-2002

- NFPA = National Fluid Power Association (USA)
- Practice adopted in March 2002
- Defined 2 methods for Viscosity Selection
  - **TOW** (**T**emperature **O**perating **W**indow)
    - Conventional hydraulic oils (95 <VI<105)
  - **ALTOW** (**AL**ternate **TOW**)
    - High VI hydraulic fluids (VI>120)
    - Addresses needs of pumps with stringent viscosity requirements

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Deficiencies of NFPA Practice

- Complex system
  - Depends on oil marketers labeling oils using the “L grade” system defined by ASTM D6080
  - Difficult to market
    - Need to educate customers & sales force
    - Need a chart to define the Low and High Temperature Grade required by each pump over a specific range of temperature
- Provides no information on the shear stability of the oil

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Swedish Standard SS 15 54 34 Edition 4

Viscometric Requirements for the V Grades

	Viscosity Grades		
Viscosity	V32	V46	V68
KV @ 40 ºC, mm^2/s	28.8 – 39.0	>39.0 – 57.0	> 57.0 – 74.8
KV @ -20 ºC, mm^2/s After 72 hr soaking	---	<=2400	<=5000
KV @ -30 ºC, mm^2/s After 72 hr soaking	<=4000	---	---
KV @ 100 ºC, mm^2/s After 20 hr KRL	>4.5	>6.0	>7.0

Comments on Swedish Standard

- For oils to meet this standard, they must have a VI > 200
- Most severe Shear Stability requirement
- ASTM L grades based on the same viscosity at different temperatures but Swedish Standard based on different viscosities at different temperatures

Characterization of Oils at Low Temperature

- ASTM established a grading system (L grade) based on the temperature at which an oil would reach a viscosity of 860 mm²/s (750 mPa.s or 4000 SUS).

- The ASTM grading system was used by NFPA in its practice

- The origin of the value selected is not well documented and, based on the requirements published by NPRA for 44 pump sets:
  - It covers the need of 75% of the pump sets.

- Other specifications such as the Swedish Standards include a maximum kinematic viscosity after 72 hour storage at a temperature that depends on the grade.
  - There is no correspondence between the requirements of the Swedish Standards and the ASTM D6080 grading.

Usefulness of the Current Requirements at Low Temperature

- Does either any one, or a combination of the low temperature requirements that are included in the 3 specifications discussed above, constitute a sound basis for:
  - Defining adequately Winter Grades?
  - Enabling OEMs to recommend a Winter Grade based on the knowledge of the pump requirements at low temperature and the operating conditions?
  - Being accepted by end users as a convenient and easy way to select a hydraulic fluid?

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Current Acceptance Status of the Characterization of Oils at Low Temperature

- The lack of acceptance of the low temperature grading system leads people needing an HF oil with good low temperature performance to select:
  - An SAE 10W engine oil
  - An ATF fluid

- This situation represents a potential risk to the equipment because these two types of fluids are not formulated for HF applications and may fail to provide the necessary level of viscosity at high temperature needed to ensure proper & efficient operation

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Defining a Selection Process for Providing Smooth Low Temperature Operation

- Work conducted in modern vane and piston pumps showed that the fresh oil VI has to be equal to at least 160 to significantly improve pump efficiency at high temperature.

- We thus propose using:
  - a VI of 160
  - A KV @ 40 °C equal to the mid-point of the ISO grade considered

  to determine the minimum temperature above which a pump will operate at a viscosity below the maximum specified by the OEM.

- For a given viscosity at 40 °C, the higher the VI, the better low temperature performance. Therefore, oils with a VI higher than 160 will provide even better low temperature performance.

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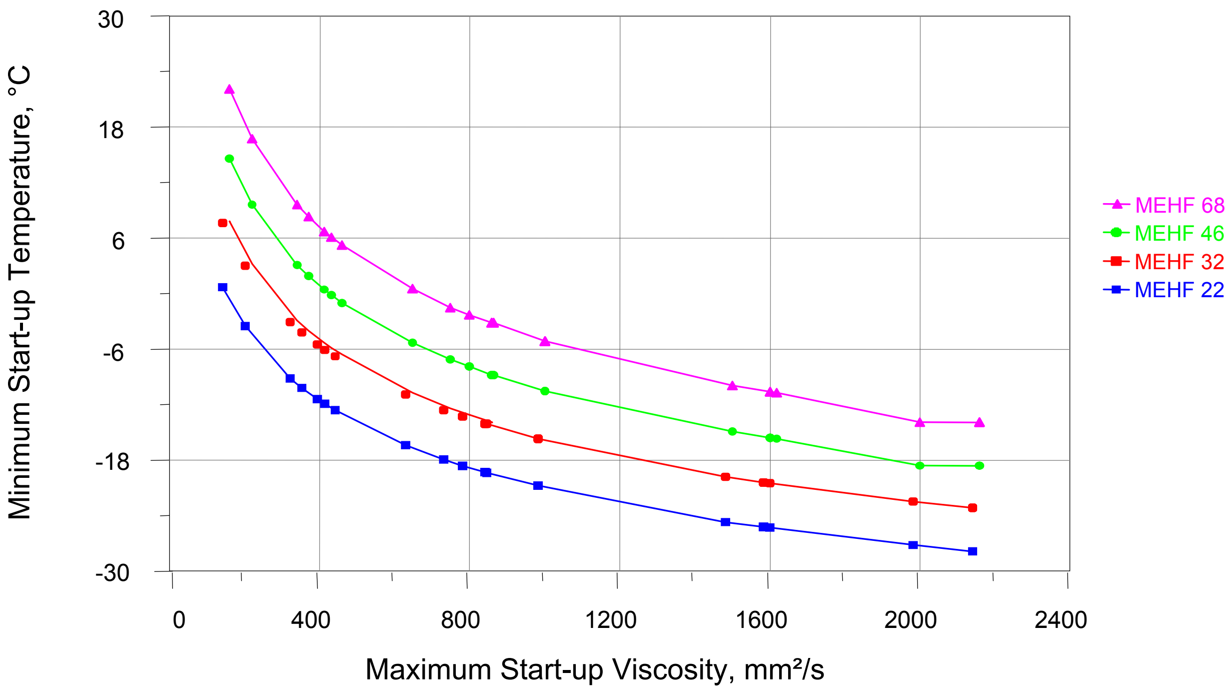
Minimum Start-up Temperature as a function of the MEHF Grade and Maximum Start-up Viscosity



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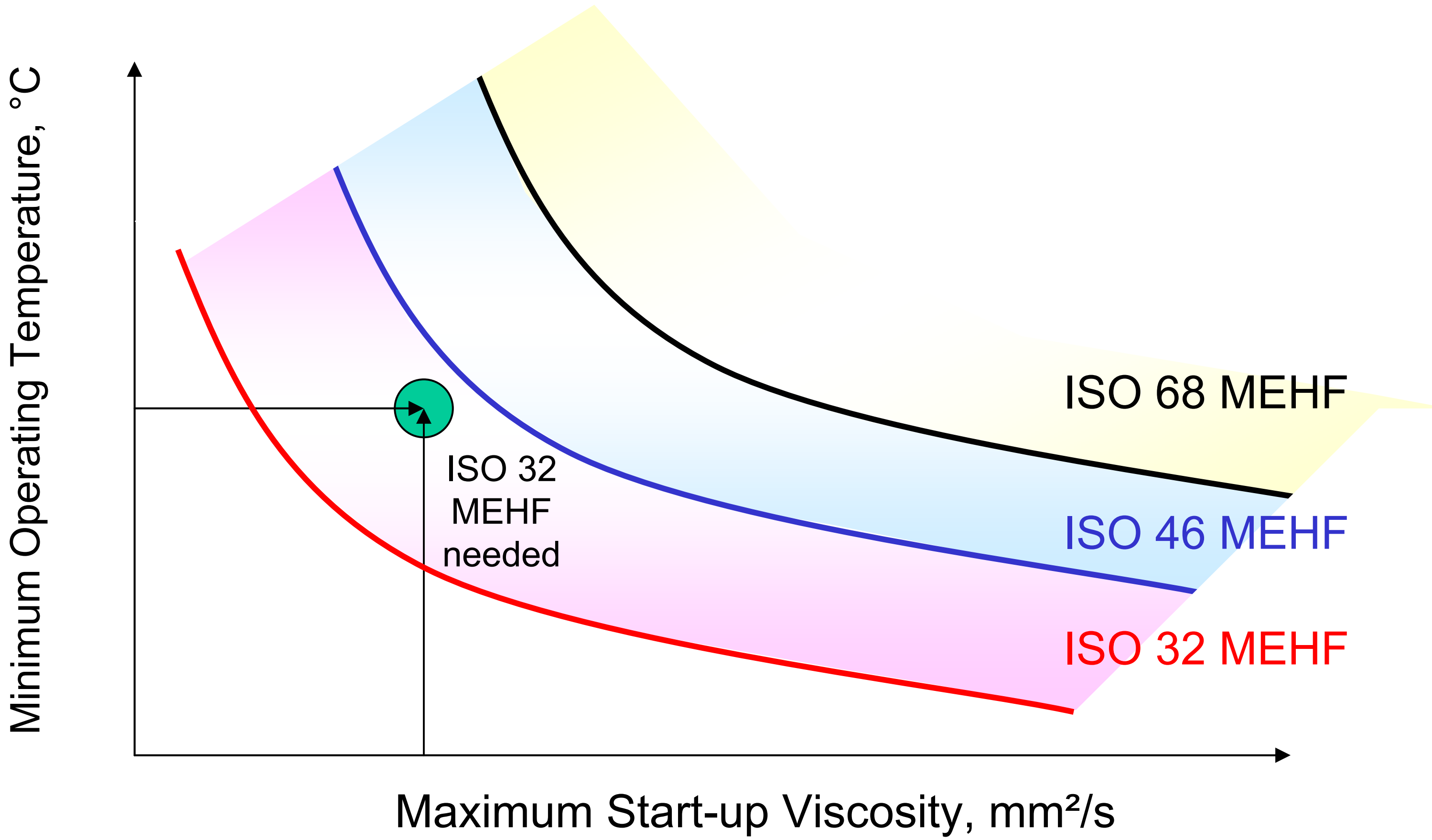
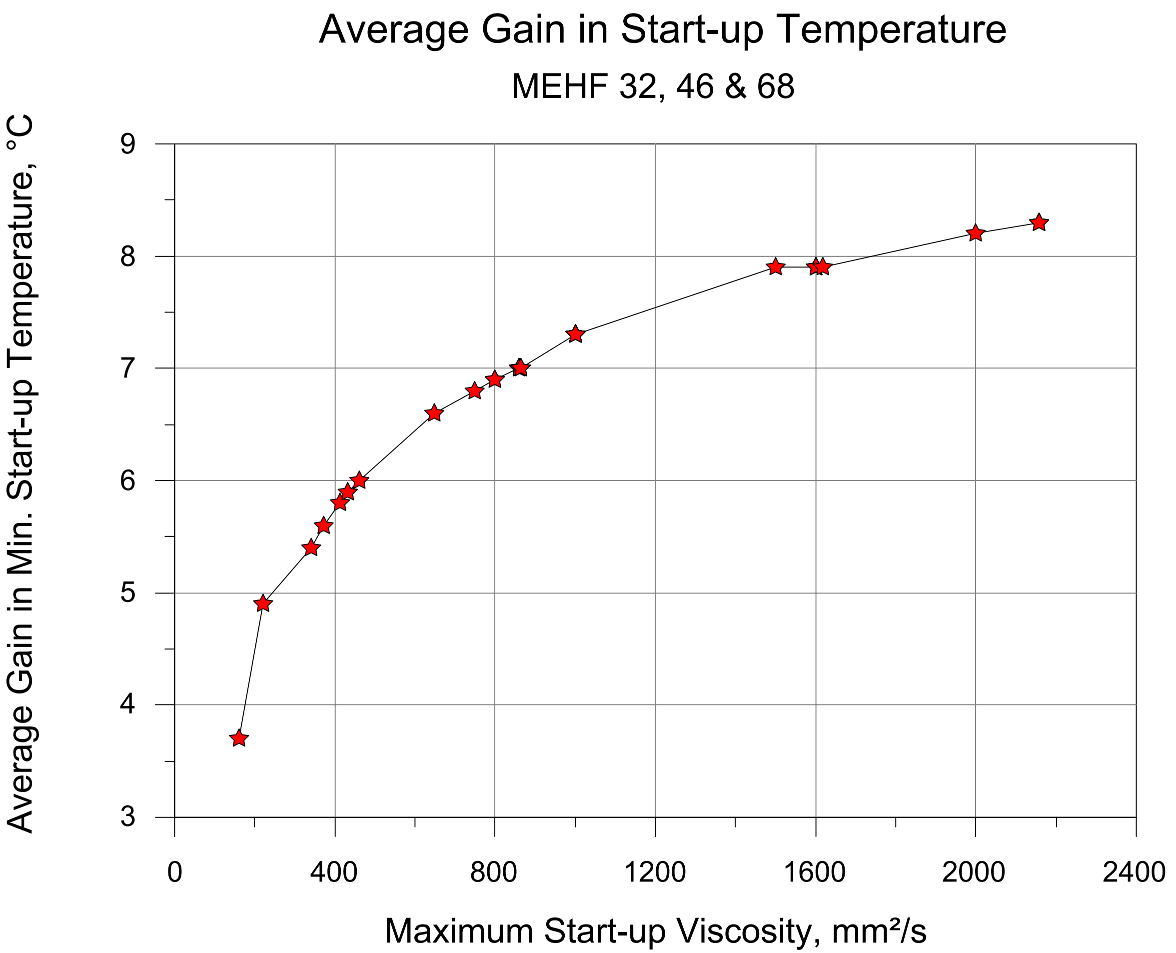
Minimum Start-up Temperature as a function of Grade and Maximum Start-up Viscosity



Minimum Start-up Temperature as a function of Grade and Maximum Start-up Viscosity

Pump Type	Maximum Start-up Viscosity, mm^2/s	Minimum Temperature MEHF 32, °C	Minimum Temperature MEHF 46, °C	Minimum Temperature MEHF 68, °C
1	800	-13	-8	-2
2	1000	-16	-11	-5
3	1500	-20	-15	-10

Average Gain in Start-up Temperature as a function of the Max. Start-up Viscosity



Benefits of MEHF Oils at Low Temperature Based on Improved Global Efficiency

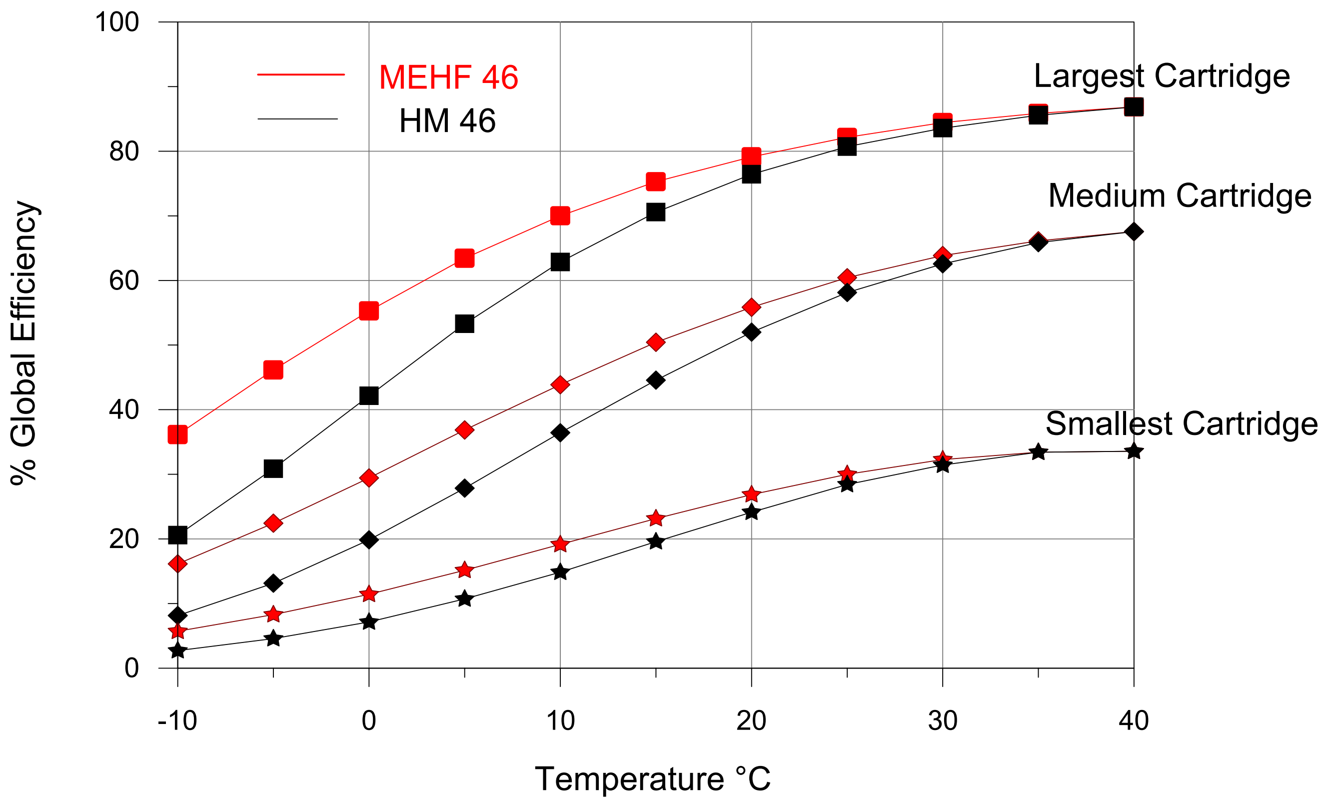
- MEHF oils with a VI equal to at least 160 will have a lower viscosity than conventional HM oils at all temperatures below 40 °C

- This lower viscosity results in lower frictional losses under conditions where the Volumetric Efficiency is close to 100%.

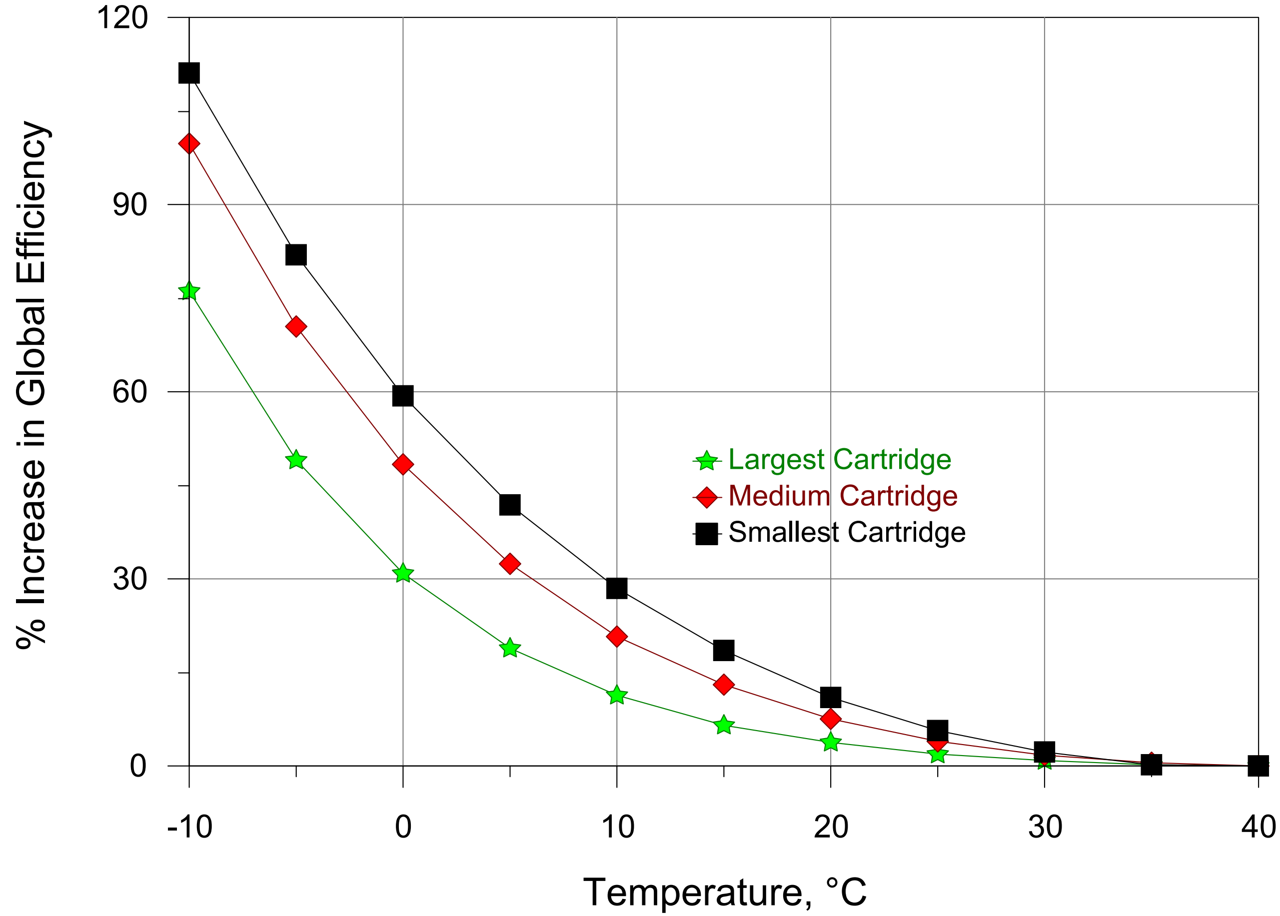
- Therefore, MEHF oils should provide higher Global Efficiency (Volumetric efficiency * Hydro-mechanical efficiency).

- We estimated the global efficiency for oils used in a T6C mobile vane pump operating at 600 rpm and 100 bars with different oils and different cartridges.

Global Efficiency at Low Temperature
T6C Mobile Vane Pump, HM 46 vs. MEHF 46



% Increase in Global Efficiency at Low Temperature T6C Mobile Vane Pump, HM 46 vs. MEHF 46



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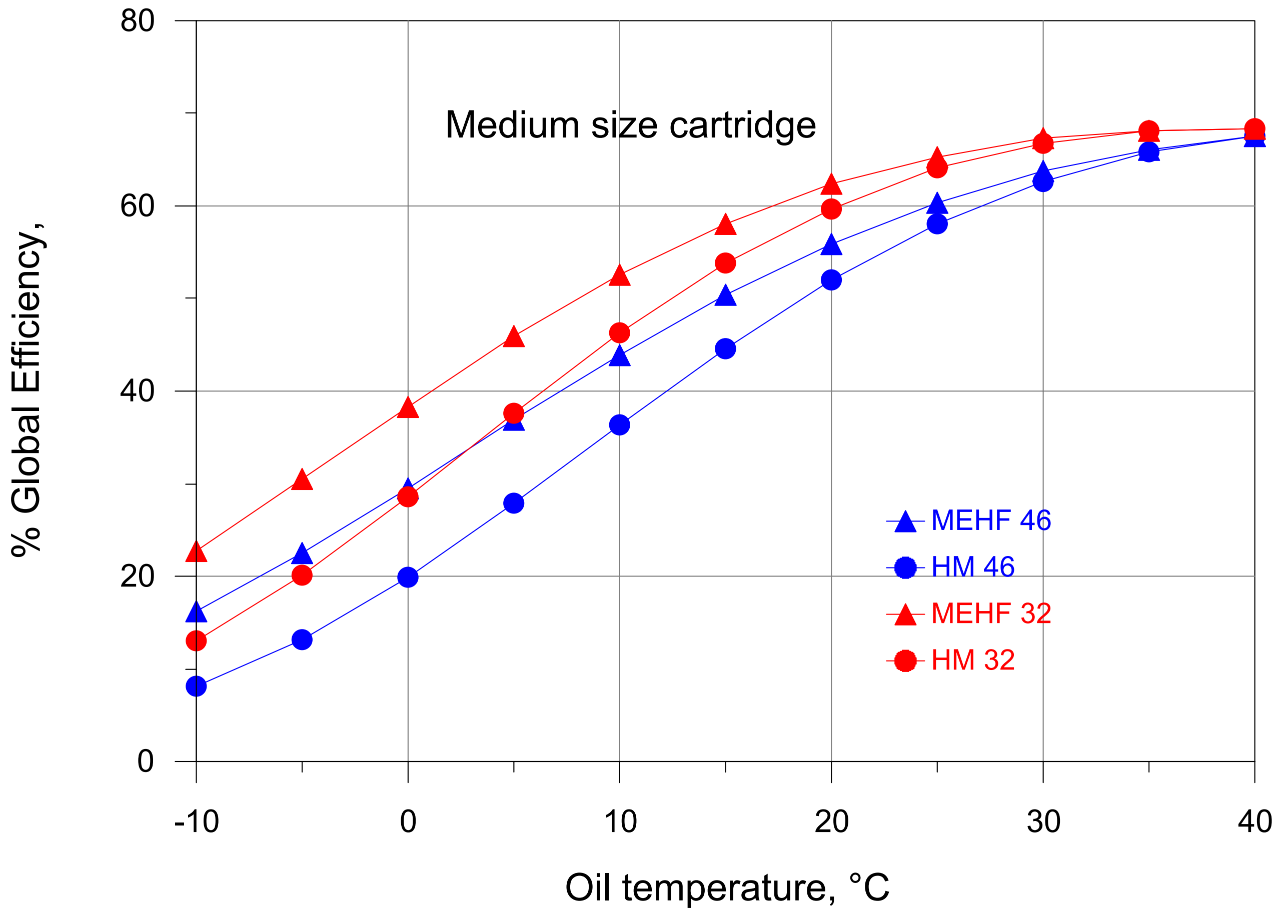
Global Efficiency at Low Temperature
T6C Mobile Vane Pump, MEHF vs. HM oils



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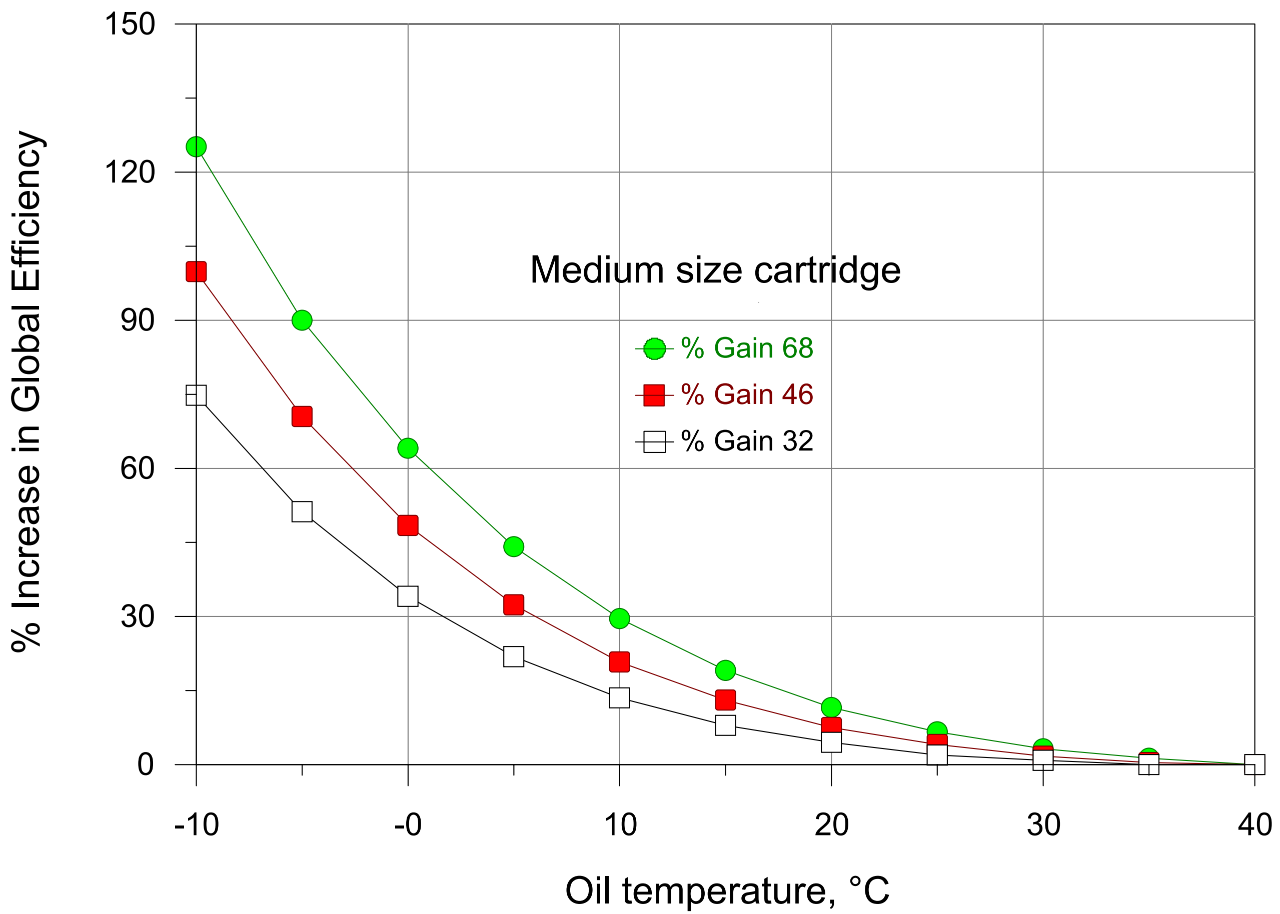
% Increase in Global Efficiency at Low Temperature T6C Mobile Vane Pump, MEHF vs. HM oil



Summary of the Benefits of MEHF at Low Temperature

- The MEHF grade concept will enable end users and OEMs to more easily select the fluid needed to operate a pump at low temperature.

- MEHFs offer the following benefits over HM fluids of the same ISO grade:
  - Lower minimum start-up temperature of about 5 °C
  - Significantly higher global efficiencies that should result in lower energy consumption
  - Reduced emissions at low temperature start-up conditions