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Hydraulic Fluid Selection and Design to Meet OEM In-Service Viscosity Requirements

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Introduction

The NFPA practice provides information on 44 different sets of pumps from 14 different OEM's

- maximum viscosity at start-up
- minimum viscosity at peak operating temperature

Using this information, we can determine the level of severity of each pump set by using the Temperature Operating Window (TOW) obtained with the 3 most popular hydraulic grades

- ISO VG 32, 46 and 68

Viscosity Index effects pump TOW – we will consider:

- VI = 100 (monograde) and VI = 150

A new approach to fluid selection based on its ability to provide adequate viscosity to several pump sets over a given range of temperature will be presented.

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NFPA Recommended Practice T2.13.13-2002

Manufacturer	Equipment	Operating		Start-up (Under Load) Maximum	Optimum
		Minimum mm²/s(cSt)	Maximum mm²/s(cSt)	mm²/s(cSt)	mm²/s (cSt)
Dension Hydraulics SPO-AM305	Piston Pumps	10	162	1618	30
	Vane Pumps	10	107	860 (low speed and pressure)	30
Dynex/Rivett axial piston pumps	PF4200 Series	1.5	372	372	20-70
	PF2006/8, PF/PV4000 and PF/PV6000 Series	2.3	413	413	20-70
	PF1000, PF2000 and PF3000 Series	3.5	342	342	20-70
Eaton	Heavy Duty Piston Pumps and Motors, Medium Duty Piston Pumps and Motors Charged Systems, Light Duty Pumps	6	--	2158	10-39
	Medium Duty Piston Pumps and Motors-Non charged Systems	6	--	432	10-39
	Gear Pumps, Motors, and Cylinders	6	--	2158	10-43
Eaton-Vickers	Mobile Piston Pumps	10	200	860	16-40
	Industrial Piston Pumps	13	54	220	16-40
	Mobile Vane Pumps	9	54	860	16-40
	Industrial Vane Pumps	13	54	860	16-40
Eaton-Char-Lynn	J, R, and S Series Motors, and Disc Valve Motors	13	--	2158	20-43
	A Series and H Series Motors	20	--	2158	20-43
Haldex Barnes	W Series Gear Pumps	11	--	750	21
Kawasaki P-969-0026 P-969-0190	Staffa Radial Piston Motors	25	150	2000 (no load)	50
	K3V/G Axial Piston Pumps	10	200	1000	

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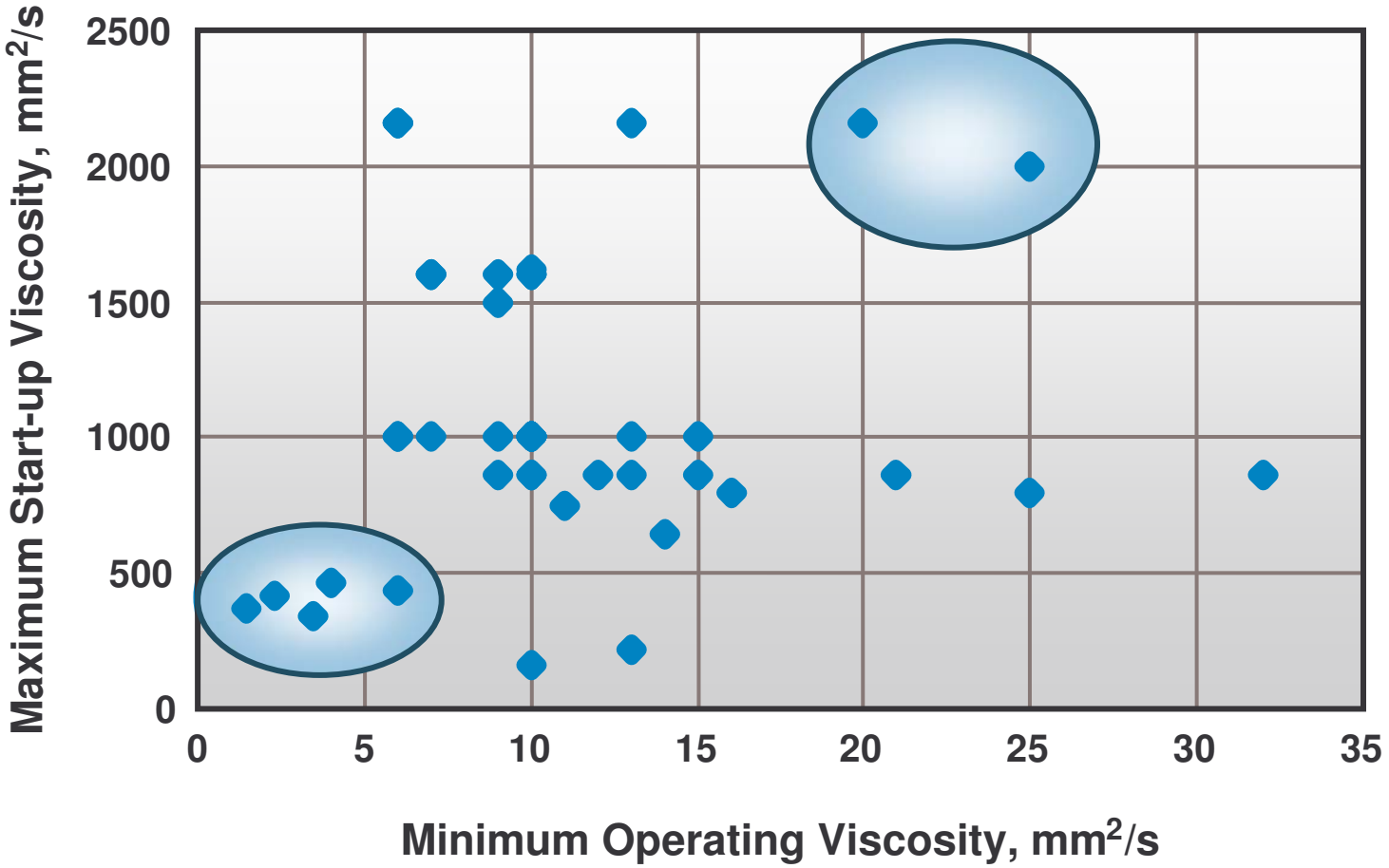
Severity of the Pumps Based on Limiting Viscosities



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Determining the TOW of each Pump Set

We have determined the temperature (T_{Min}) at which a given ISO grade with a VI of 100 reaches the Maximum Start-up Viscosity.

We have determined the temperature (T_{Max}) at which a given ISO grade with a VI of 100 reaches the Minimum Operating Viscosity.

The TOW for a given grade is thus defined by

$$TOW = T_{Max} - T_{Min}$$

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Determining the TOW of each Pump Set / II

Manufacturer	Equipment	Type	Minimum	Maximum	ISO 32 VI=100		
			mm^2/s (cSt)	mm^2/s (cSt)	T_{Max}	T_{Min}	TOW32
Rexroth Corporation	SV-40, 80 and 100 VPV 45, 63, 80, 100, 130,164		32	864	40,0	-6,8	46,8
Rexroth Corporation	V3 , V4, V5, V7 Pumps		25	800	45,6	-6,0	51,6
Eaton - Vickers	Industrial Piston Pumps	P	13	220	63,7	8,2	55,5
Rexroth Corporation	Q, Q-6, SV-10, 15, 20, 25, VPV 16, 25, 32		21	864	50,0	-6,8	56,8
Rexroth Corporation	Radial Piston (SECO)	RP	10	162	71,5	12,2	59,3
Kawasaki P-969-0026	Staffa Radial Piston Motors	RP	25	2000	45,6	-14,2	59,8
Rexroth Corporation	V2 Pumps		16	800	57,4	-6,0	63,4
Rexroth Corporation	Axial and RKP Piston	P	14	647	61,3	-3,9	65,2
Eaton - Char-Lynn	A Series and H Series Motors		20	2158	51,2	-14,8	66,0
Rexroth Corporation	FA, RA,; K		15	864	59,3	-6,8	66,1
Rotary Power	'SMA' Radial Piston Motor	RP	15	1000	59,3	-8,1	67,4
Eaton - Vickers	Industrial Vane Pumps	V	13	860	63,7	-6,7	70,4
Parker Hannifin	VCR2 Series		13	1000	63,7	-8,1	71,8
Sauer-Danfoss, GmbH	Series 15 Open Circuit		12	860	66,3	-6,7	73,0
Haldex Barnes	W Series Gear Pumps	G	11	750	69,2	-5,4	74,6
Denison Hydraulics	Vane Pumps	V	10	860	71,5	-6,7	78,2
Eaton - Vickers	Mobile Piston Pumps	P	10	860	71,5	-6,7	78,2
Eaton - Char-Lynn	J, R, and S Series Motors, and Disc Valve Motors		13	2158	63,7	-14,8	78,5
Kawasaki P-969-0190	K3V/G Axial Piston Pumps	AP	10	1000	71,5	-8,1	79,6
Linde	All		10	1000	71,5	-8,1	79,6

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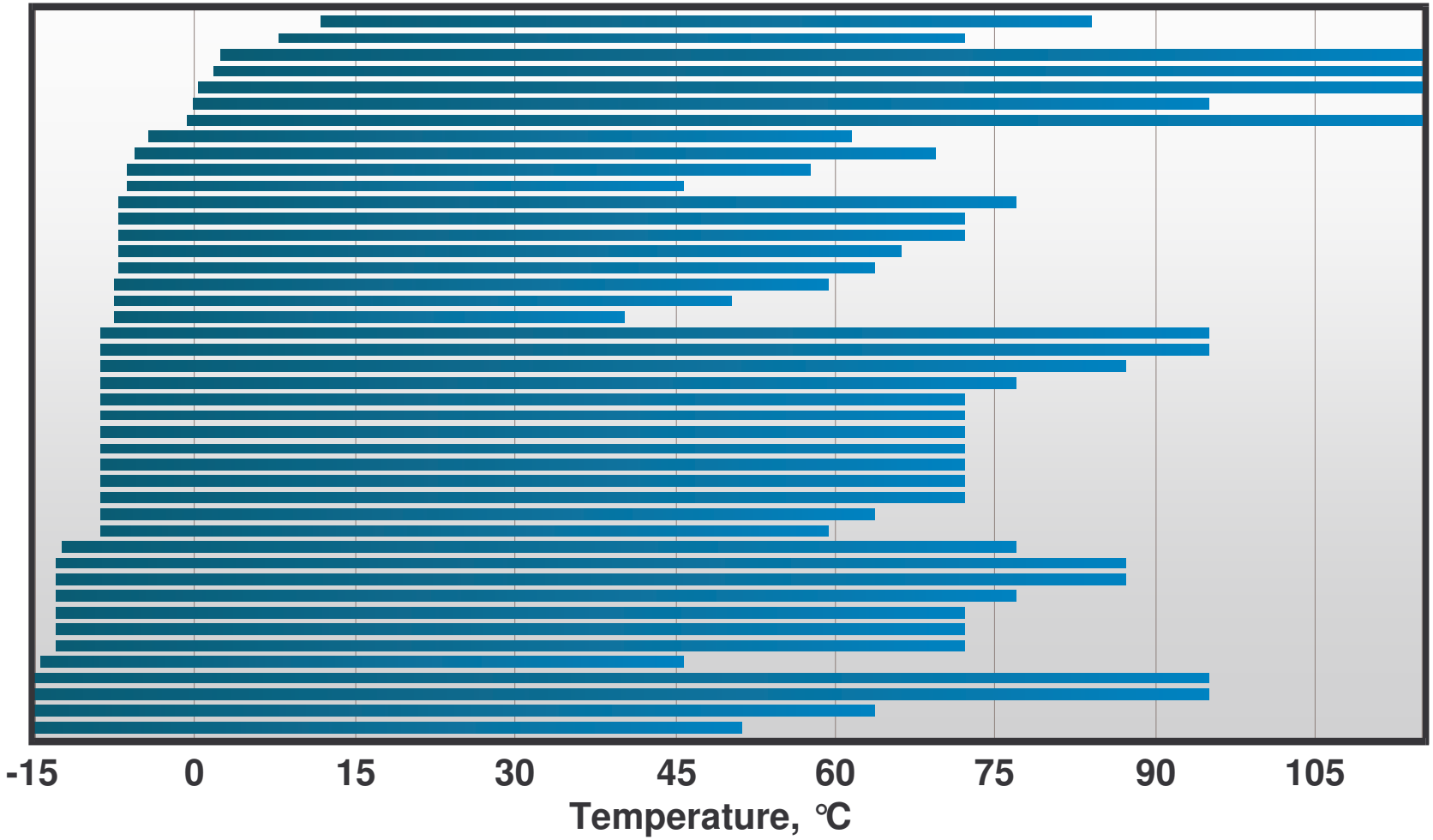
Pump TOWs Using an ISO 32 Monograde Fluid



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Defining Pump TOW Severity

High Pump Severity

- Pump viscosity requirements do not allow for large changes in fluid temperature (<80°C from Start-up to Peak operating temp.) when using a monograde VI = 100 fluid.

Low Pump Severity

- Pump can tolerate large changes in fluid temperature and still meet OEM viscosity guidelines (>100°C Start-up to peak operating temperature) when using a monograde VI = 100 fluid.

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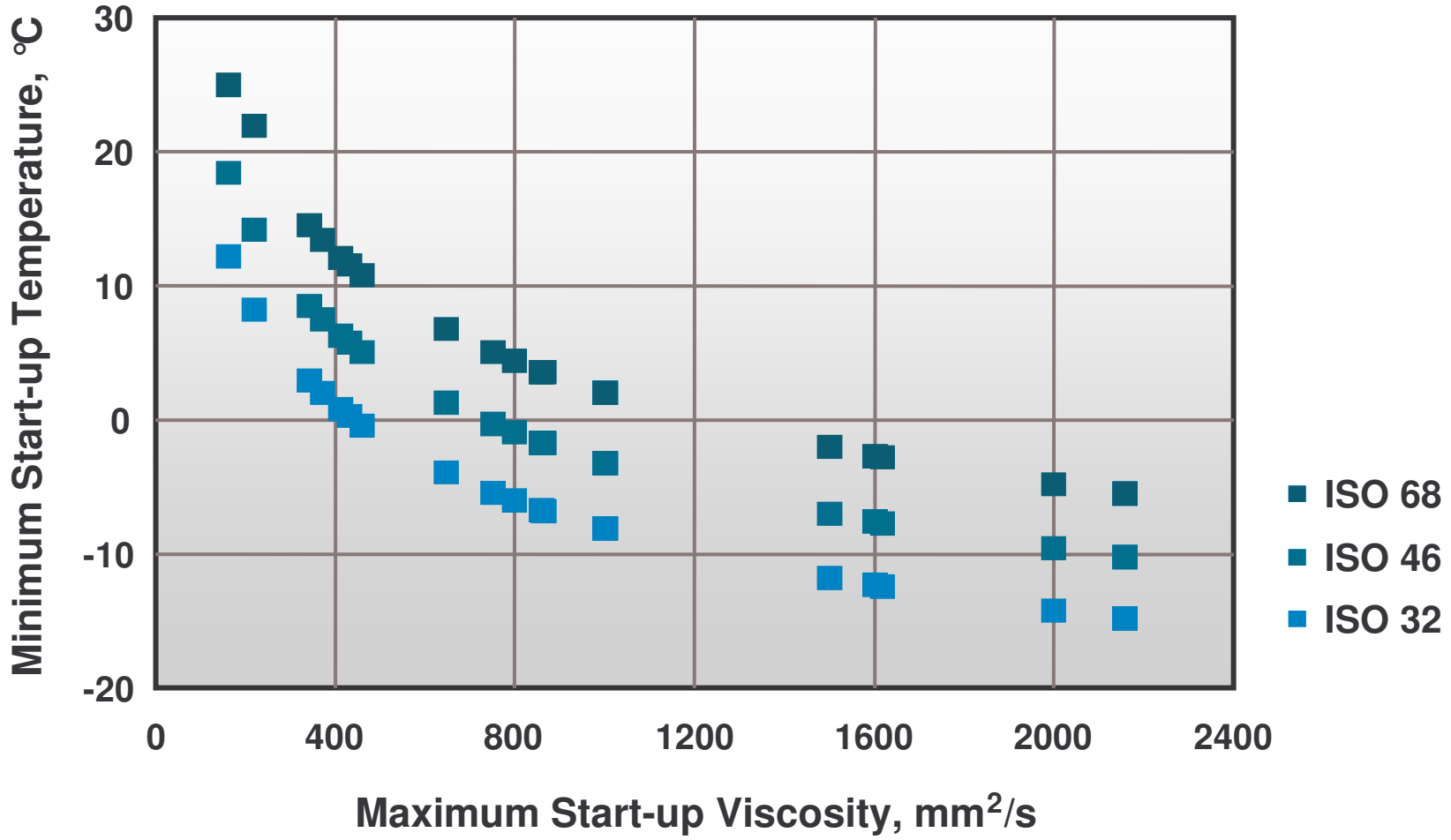
Minimum Operating Temperature = $f(KV_{Max})$



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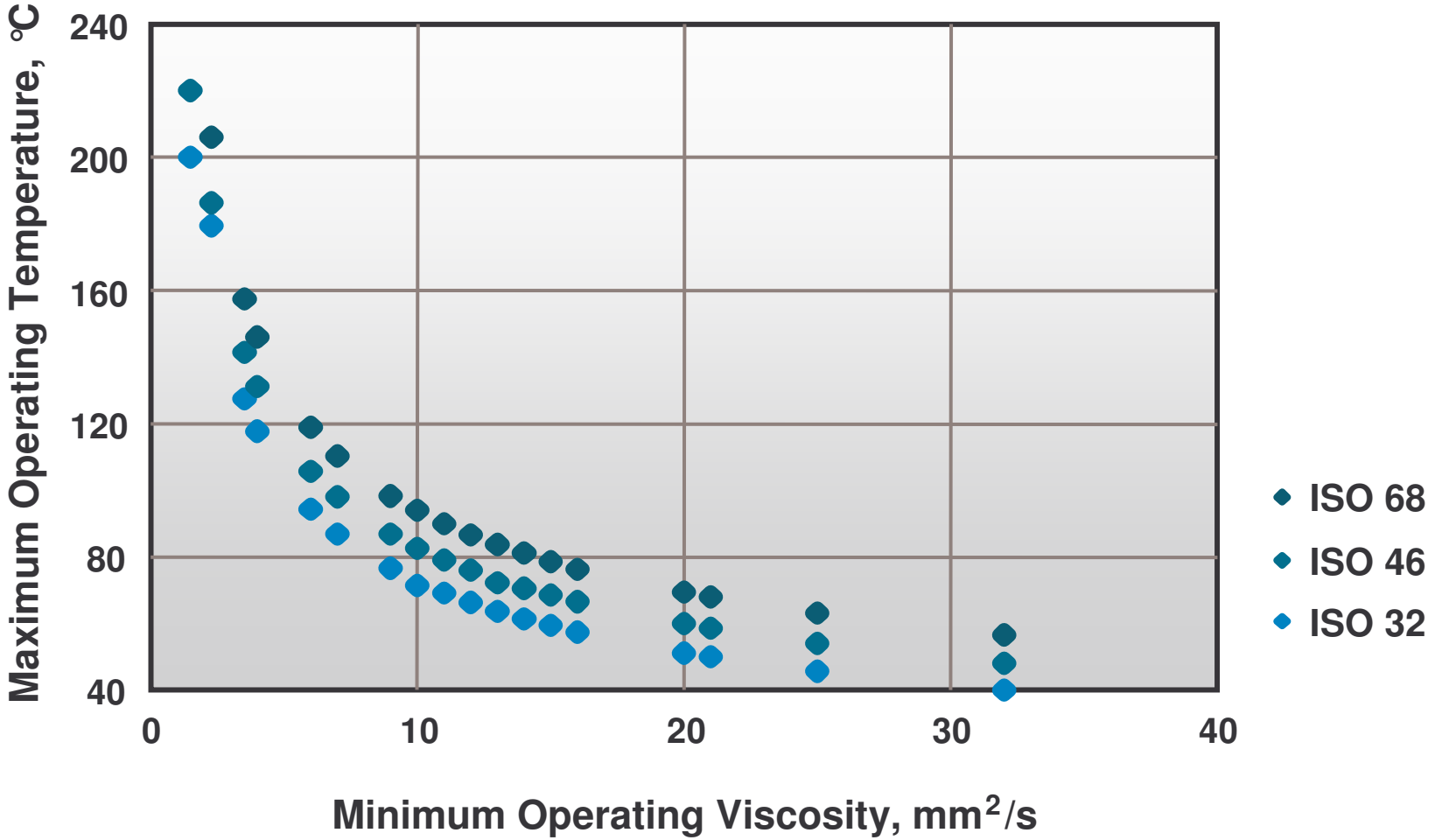
Maximum Operating Temperature = $f(KV_{Min})$



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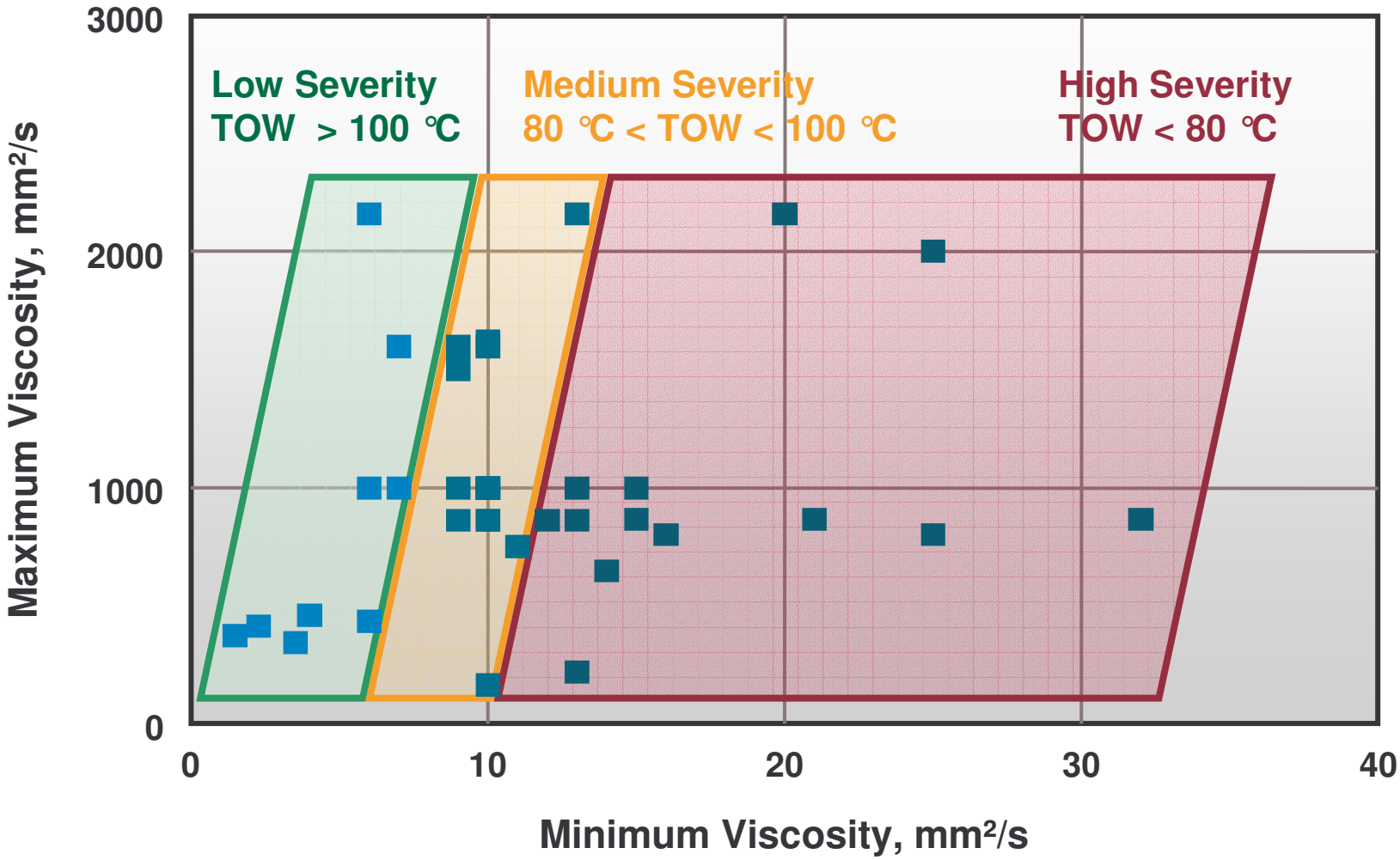
Severity of the Pumps Based on Average TOW



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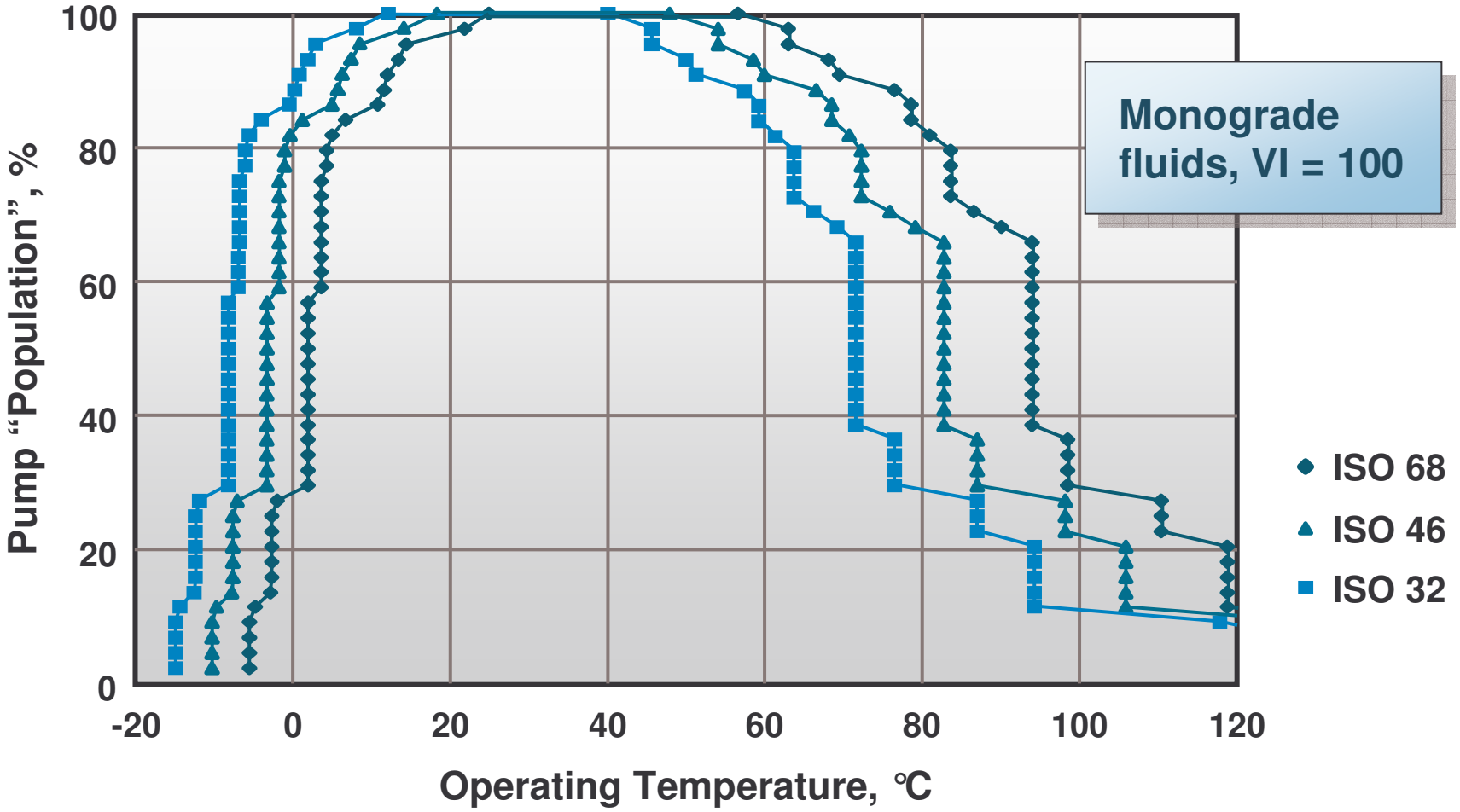
Percentage of Pumps that can Operate with a Given Fluid



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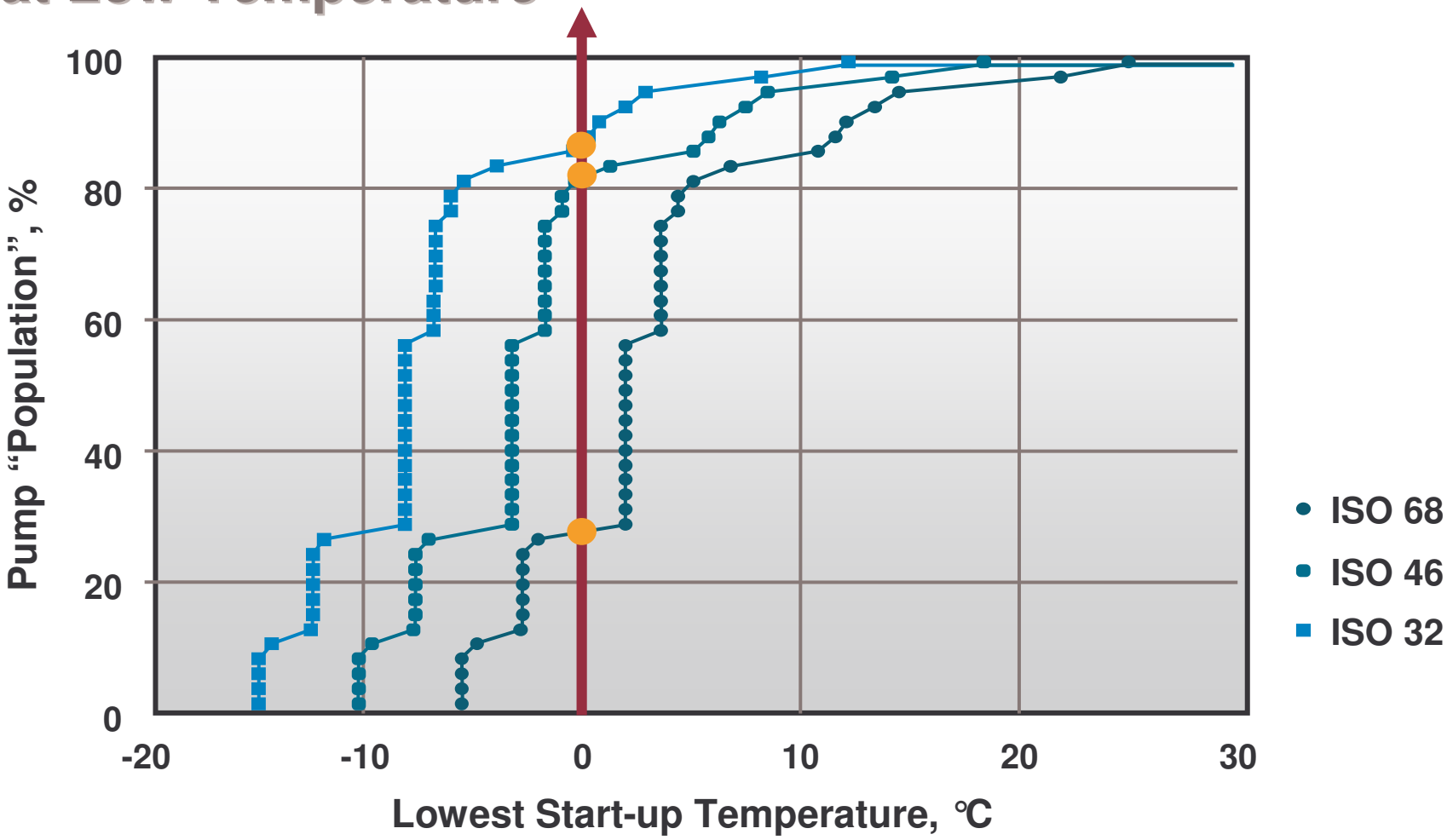
Percentage of Pumps that can Operate at Low Temperature



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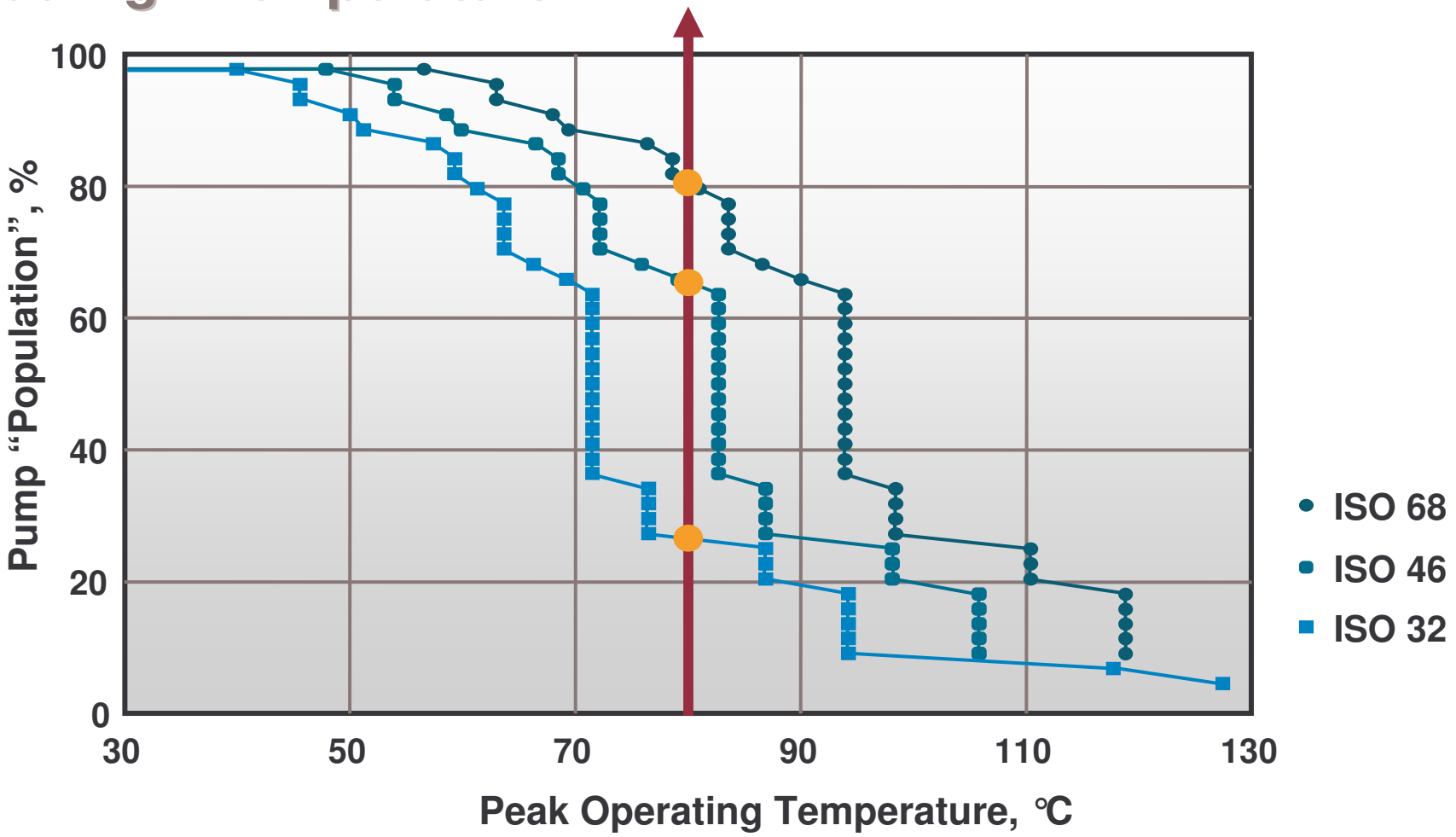
Percentage of Pumps that can Operate at High Temperature



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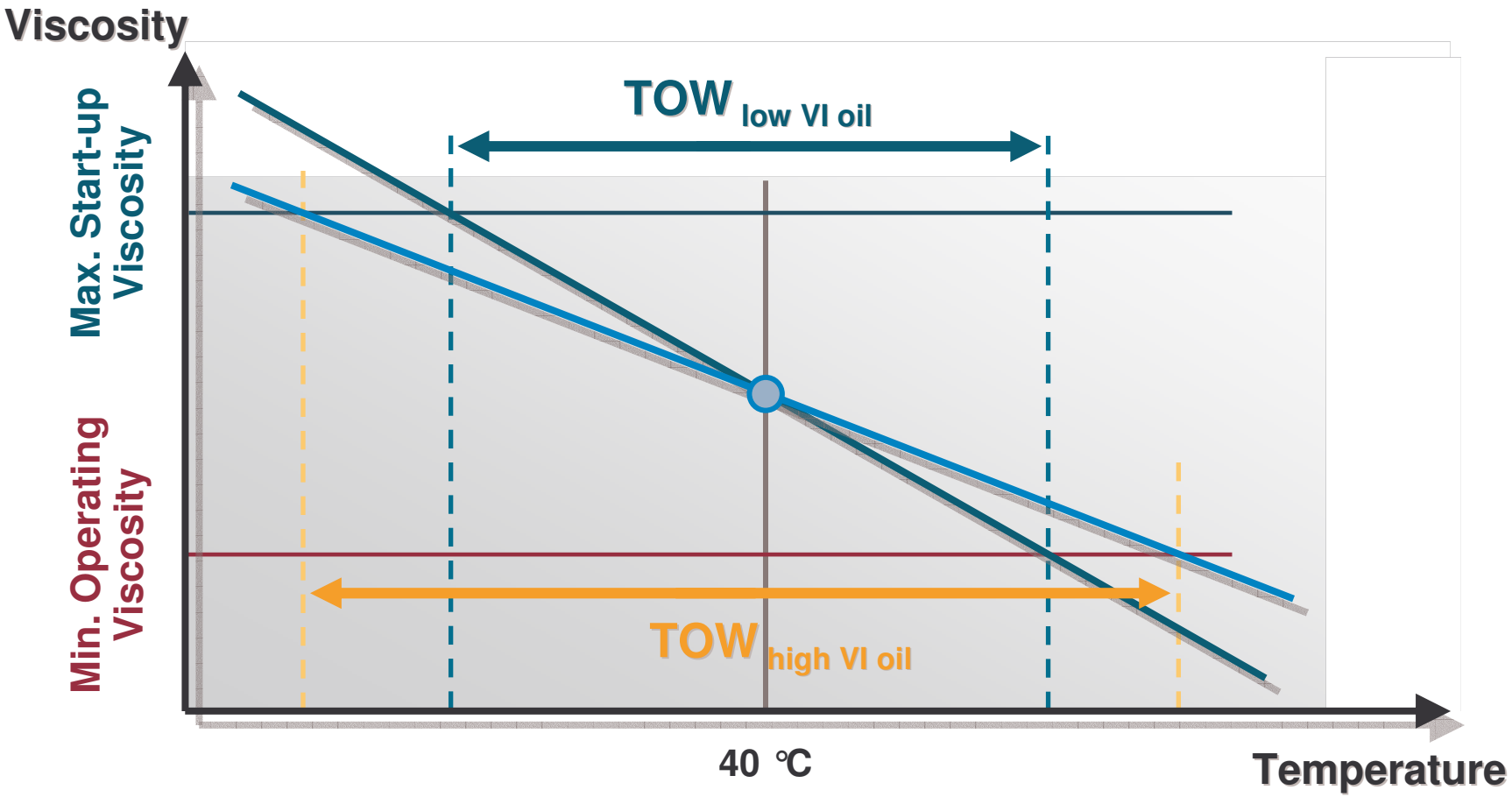
Effect of the VI on the Size of TOW



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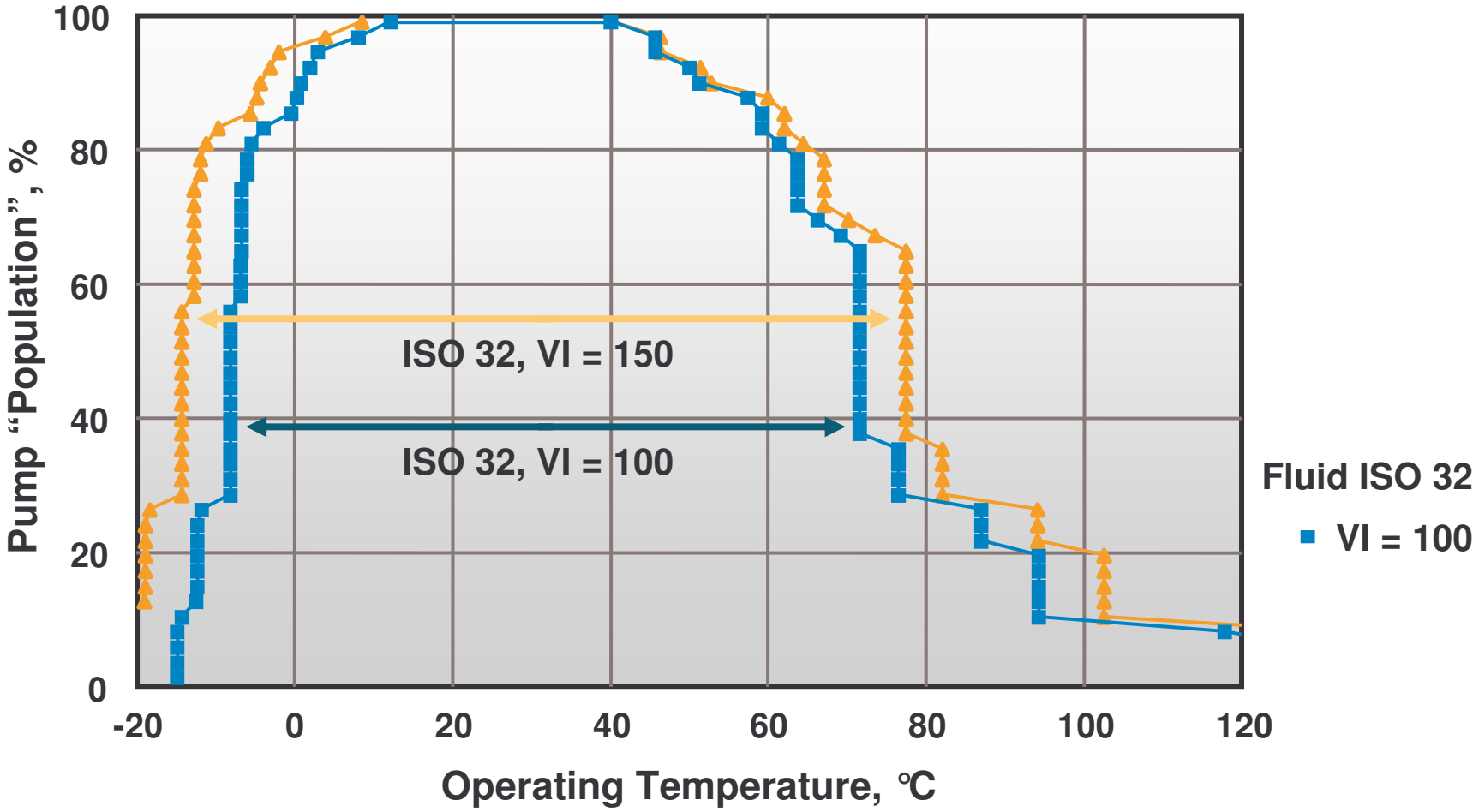
Improvement in Percentage of Pumps that can Operate due to High VI Fluids



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Average TOW for the 44 Pump Sets as a Function of VI and ISO Grade

	Average TOW for the 44 Pump Sets, °C		Increase in Average TOW, °C
ISO Grade	VI = 100	VI = 150	
32	86.5	96.8	**10.3**
46	92.5	106.0	**13.5**
68	99.1	114.3	**15.2**

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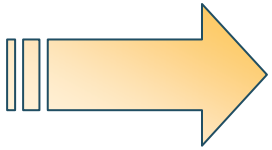
Viscosity Grade Selection Example

Manufacturer	Equipment	Minimum	Maximum
		mm^2/s	mm^2/s
Eaton - Char-Lynn	J,R, and S Series Motors	**13**	**2158**
Poclain Hydraulics	H and S Series Motors	**9**	**1500**
Denison Hydraulics	Piston Pumps	**10**	**1618**
All 3 manufacturers	**All 3 sets of pumps**	**13**	**1500**



Peak Operating Temperature	Start-Up Temp.	ISO Grade	VI
60 °C	0 °C	32	100

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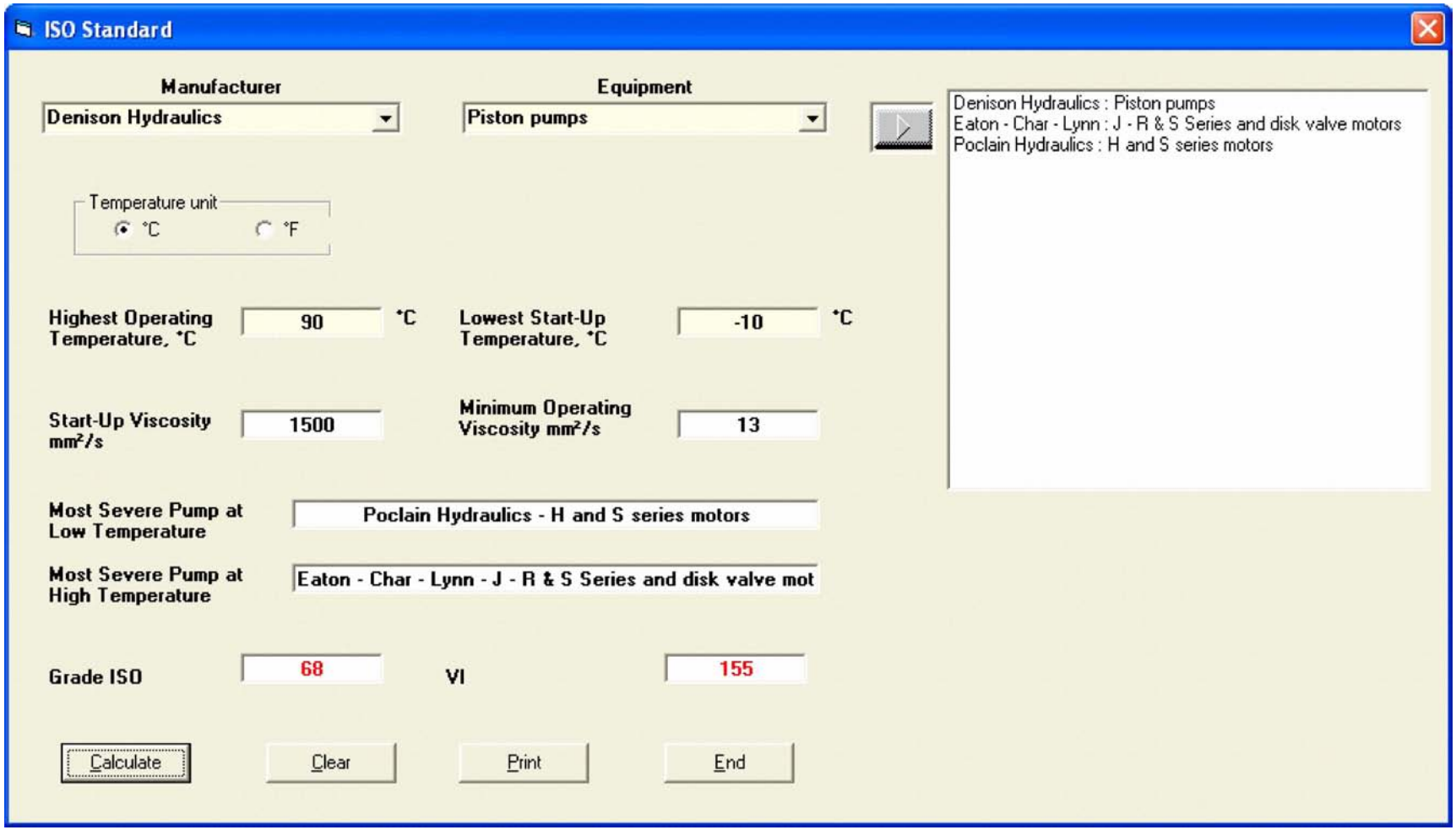
Computer Aided Viscosity Grade Selection



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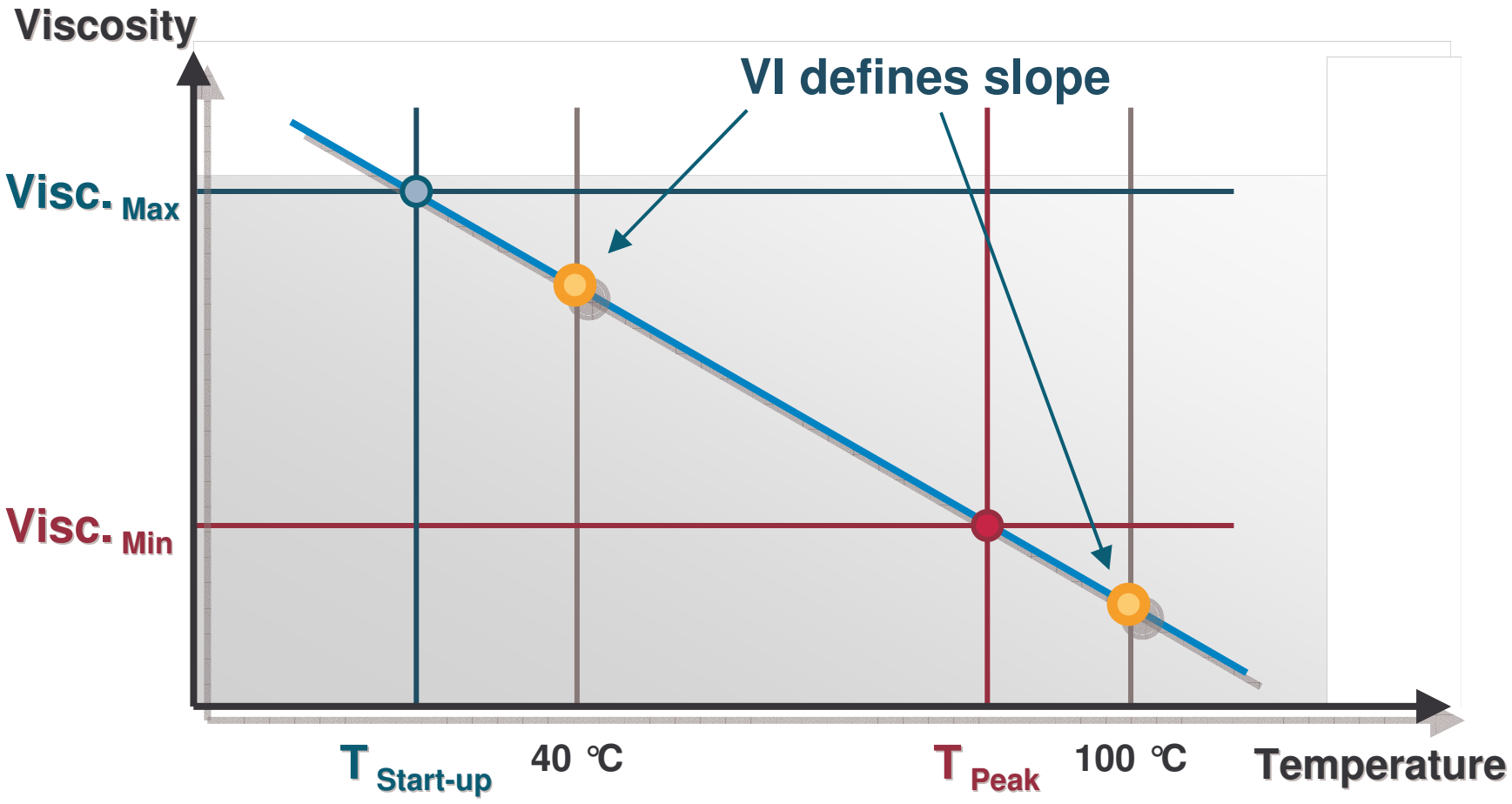
TOW of a Pump Set Using a Given ISO Grade and VI



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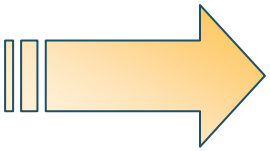
TOW Calculation Based on a Given Viscosity Grade

Manufacturer	Equipment	Minimum	Maximum
		mm^2/s	mm^2/s
Eaton - Char-Lynn	J,R, and S Series Motors	**13**	**2158**
Poclain Hydraulics	H and S Series Motors	**9**	**1500**
Denison Hydraulics	Piston Pumps	**10**	**1618**
All 3 manufacturers	**All 3 sets of pumps**	**13**	**1500**



ISO Grade	VI	Peak Operating Temperature	Start-Up Temp.
32	100	64 °C	-12 °C
32	150	67 °C	-18 °C
46	100	73 °C	-7 °C
46	150	79 °C	-14 °C

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Conclusions

Using the OEM viscosity guidelines summarized in the NFPA recommended practice, we can calculate the TOW for any hydraulic fluid in any pump.

- It can be challenging to meet the viscosity requirements of several pump sets with one fluid viscosity grade.
- High VI hydraulic fluids can be used to increase the performance of any pump, or set of pumps.
- Increasing fluid VI from 100 to 150 will:
  - Increases the pump TOW by 10 – 15 °C
  - Significantly increase the percentage of pump sets that can be satisfied with a single fluid
  - Reduce maintenance and fluid inventory complexity/costs

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Conclusions

High Performance Hydraulic Fluids can be formulated using PAMA viscosity index improvers:

- Specifically designed for high pressure hydraulic fluid service
- Optimized shear stability
- Minimum treat rate and formulation economics
- Wider Temperature Operating Window (TOW)
- Higher pump efficiency
  - Reduced fuel consumption and energy costs
  - Reduced emissions

! Simplify Hydraulic System Maintenance and Fluid Logistics

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Recommendations

Visit www.MEHF.com for general educational information about hydraulic fluid viscometrics and their impact on:

- Pump Efficiency
- Increased Power
- Energy Savings
- Simplified Maintenance and Logistics for Reduced Operating Costs

Fluids meeting the MEHF (Maximum Efficiency Hydraulic Fluid) performance level definition enable the fleet owner to meet the viscosity requirements of multiple pump manufacturers.