Hydraulic Fluid Principles and Packages

Functional Products Inc.

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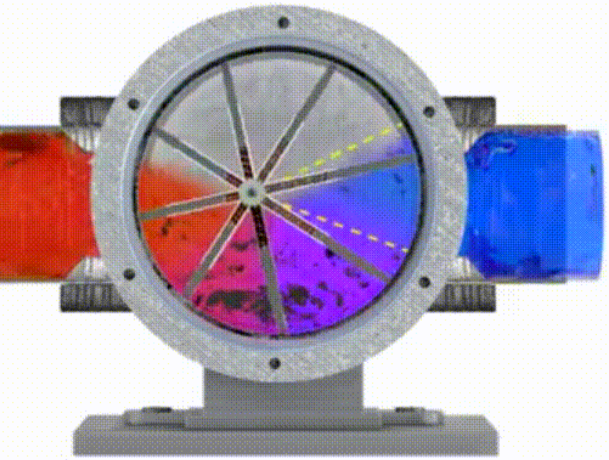
Overview

- Hydraulic fluid
  - Hydraulics
  - Formulation
  - Performance and Testing
  - Ecolabel / LuSC
  - Specifications / certifications
    - What Functional can and can't do in the HF area
- Air compressor

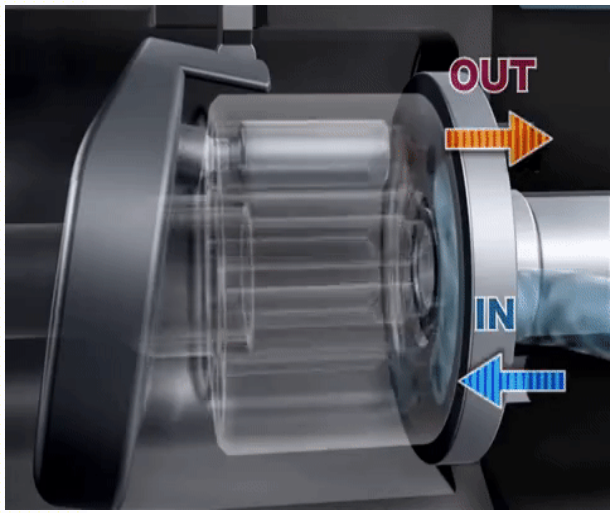
Hydraulic Pumps

- Many designs and variations
  - All compress liquid and transmit the pressure as power across a ‘circuit’

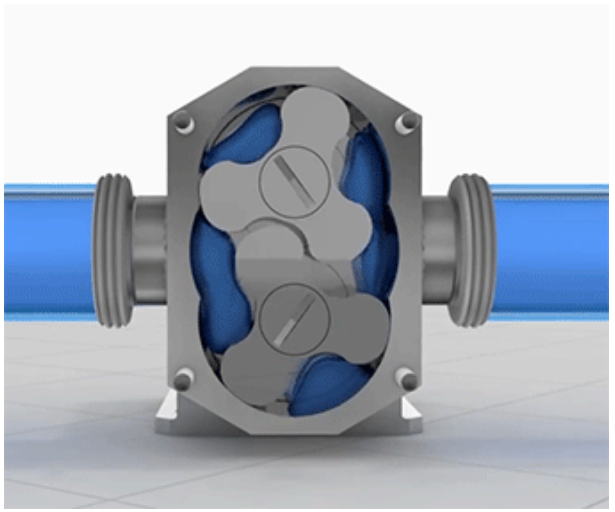
Vane Pump



Radial Piston Pump



Gear Pump

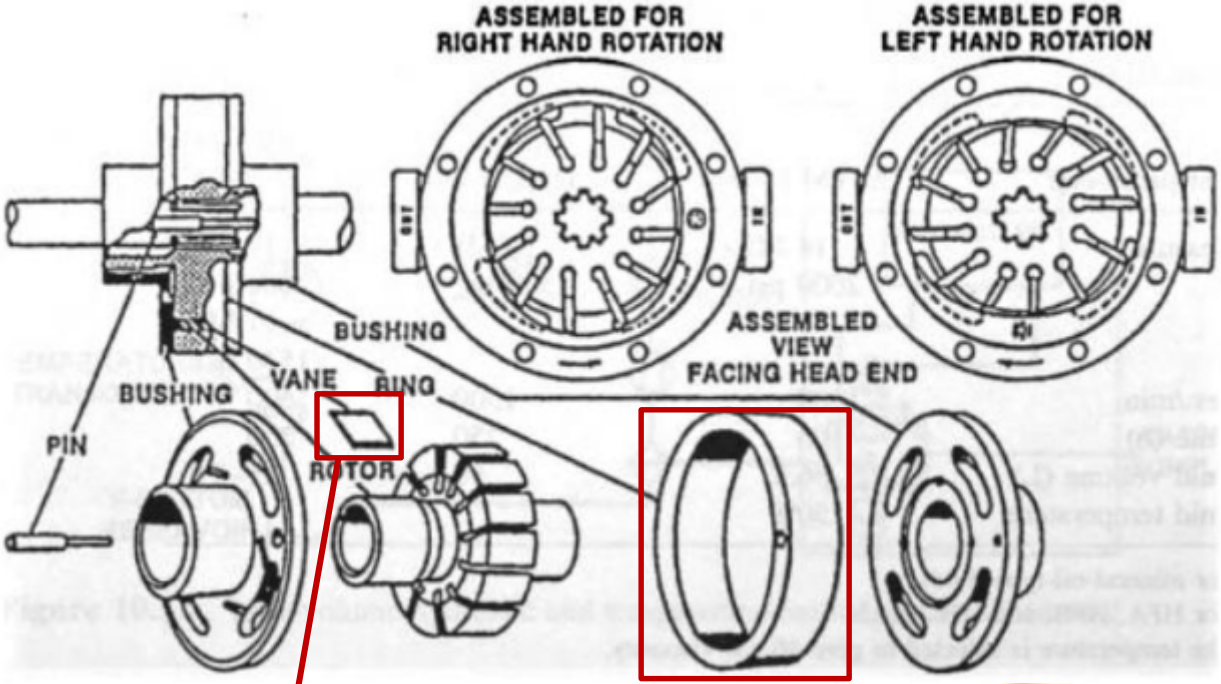


Hydraulic Wear

- Many sliding metal-on-metal elements
  - Vanes or pistons
- Rolling elements
  - Bearings and shafts
- Cavitation
  - Micro explosions of trapped air released under pressure
    - Causes surface pitting and ablation
- Hydraulic fluid must facilitate the transfer of pressure as power and ensure the mechanical systems generating/transmitting power survive

V140C - Vickers Vane Pump

- ASTM D7043
  - Critical ‘big test’ for proving a HF formulation
  - Measures wear on vanes and cam ring of vane pump



“Handbook of Hydraulic Fluid Technology”, G.E. Totten, pg. 570

HF Viscometrics

- Viscosity
  - Most commonly ISO 46
  - Some ISO 32 / 68, less ISO 100

- Viscosity index
  - Monograde (VI ~100)
  - High VI (VI 140+)
  - Some ‘very high’ VI (VI 180+)

High VI Hydraulic

- High VI hydraulic fluids
  - Typically require a high VI base oil or VI improver polymer
  - Viscosity changes less with temperature
    - One grade can cover all seasons of hot and cold fluctuations
      - Especially important for mobile equipment
    - Less power fade as the fluids warms up after start-up

HF Formulation

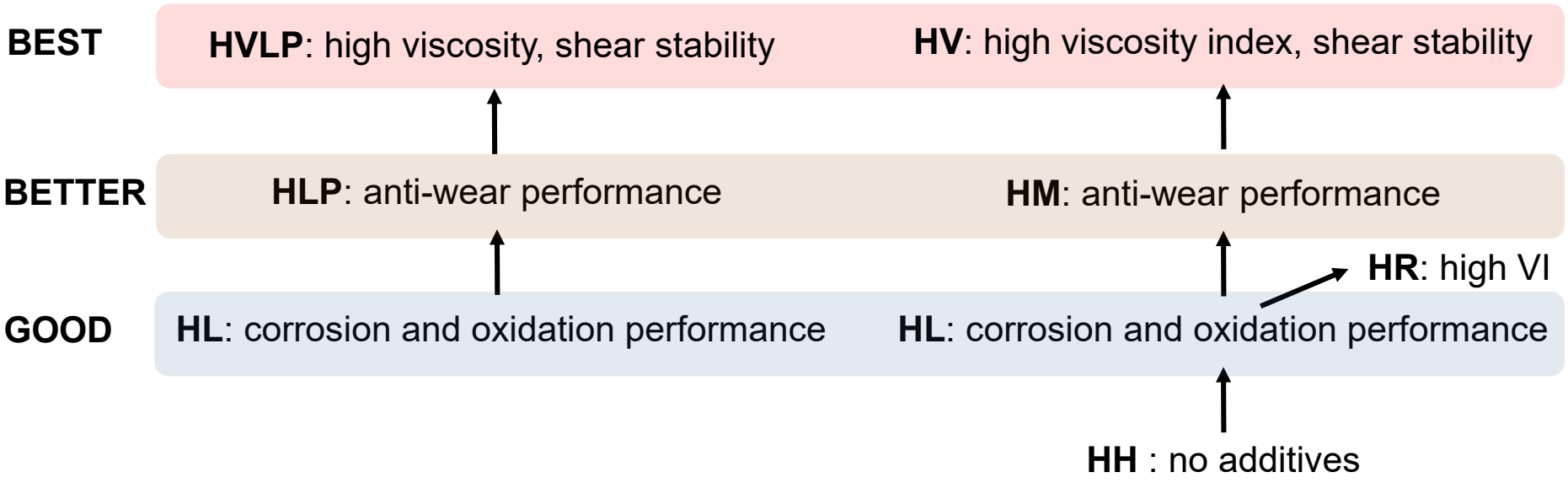
- Functional HF packages
  - HF-580 – 2.5wt% versatile and robust metal-free package
    - Wide variety of compatible base fluids
    - Cross-over into air compressor
  - HF-595 – 2.2wt% Ecolabel/LuSC certified for EAL hydraulics

Performance Testing

- What do you need to prove the utility of an HF package or formulation?
  - Pre-screening bench tests - $100-300/per
    - 4-ball wear (D4172, 40kg)
    - Demulsibility (D1401)
    - Defoaming (D892), Schedule I/II/III
    - Seal swell (D4289 / D6546 / etc.)
    - Oxidation stability (D2272), RPVOT
    - Shear stability (D5621 “sonic” or CEC L-45-99-A “20hr KRL”)
  - Pump testing - $2000-5000/per
    - Vickers V104C (D2882)

Specifications - HVLP

- Three specs (DIN / ISO / ASTM) with various designation codes



- Each tier carries the additive and performance from the tier below

- In DIN, extra letters are tacked on with each tier
- In ISO/ASTM the letters are replaced (harder to remember)

Ecofriendly HF

- Functional Products supports European Ecolabel
  - LuSC list for environmentally acceptable lubricants

- European Ecolabel program defines required toxicity, biodegradability, renewability limits on ecofriendly lubes and grease
  - Shortlist for Vessel General Permit (all maritime lubricants)
  - Minimum performance specifications for each category
    - Ecolabel hydraulic fluid must conform to **ISO 15380**

ISO 15380 for EAL

- ISO 15380 – Environmentally acceptable hydraulic fluids
  - Four categories and requirements assigned by EAL base fluid
    - **HETG** – Triglyceride and vegetable oils
    - **HEES** – synthetic esters
    - **HEPG** – polyglycols
    - **HEPR** – polyalphaolefin and related

Ecolabel HETG Specs

Test			ISO 22	ISO 32	ISO 46	ISO 68	ISO Method	ASTM Method
Density @ 15C		kg/m3	Report	Report	Report	Report	ISO 12185 ISO 3675	D4052 D1298
Color			Report	Report	Report	Report	ISO 2049	D1500
Appearance at 25C			Br & Cl	Br & Cl	Br & Cl	Br & Cl	Visual	Visual
Ash Content, max.		wt%	Report	Report	Report	Report	ISO 6245	D482
Flash Point, COC		C	>165	>175	>185	>195	ISO 2592	D92
Kinematic Viscosity								
	-20C	mm2/s	report	report	report	report	ISO 3104	D445
	0C	mm2/s	<300	<420	<780	<1400	ISO 3104	D445
	40C	mm2/s	19.8 - 24.2	28.8 - 35.2	41.4 - 50.6	61.2 - 74.8	ISO 3104	D445
	100C	mm2/s	>4.1	>5.0	>6.1	>7.8	ISO 3104	D445
Pour Point		C	report	report	report	report	ISO 3016	D97
Low temp. fludity after 7 days			report	report	report	report	ASTM D2532	D2532
Acid number, max.		mg KOH/g	report	report	report	report	ISO 6618 ISO 6619	D974 D664
Water content		mg/kg	1000	1000	1000	1000	ISO 12937 ISO 6296	D6304
Cleanliness level			report	report	report	report	ISO 4406 ISO 11500	
Copper Corrosion, 100C, 3hr			2	2	2	2	ISO 2160	D130
Rust Prevention A, 24hr			Pass	Pass	Pass	Pass	ISO 7120	D665A
Foam								
	Schedule I	ml	150/0	150/0	150/0	150/0	ISO 6247	D892
	Schedule II	ml	80/0	80/0	80/0	80/0		
	Schedule III	ml	150/0	150/0	150/0	150/0		
Air Release, 50C			<7	<7	<10	<10	ISO 9120	D3427
Water Separation (time to 3 mL emulsion, 54C)		min	report	report	report	report	ISO 6614	D1401
Elastomer Compatibility after 1000hrs (pick 2)								
	NBR 1	C	60	80	80	80	ISO 6072	
	HNBR	C	60	80	80	80		
	FKM 2	C	60	80	80	80		
	AU	C	60	80	80	80		
	Change in shore A hardness	%	+/- 10	+/- 10	+/- 10	+/- 10		
	Change in volume	%	-3 to +10	-3 to +10	-3 to +10	-3 to +10		
	Change in elongation	%	<30	<30	<30	<30		
	Change in tensile strength	%	<30	<30	<30	<30		
Oxidation Stability (dry TOST)								
Time to reach TAN = 2 mg KOH/g, min		hr	report	report	report	report	ISO 4263-3	D943
Baader Test, 95C, 72hr								
Increase in viscosity at 40C		%	<20	<20	<20	<20	DIN 51554-3	
FZG A/8,3/90		stage	N/A	10+	10+	10+	ISO 14635-1	
Vane Pump, Procedure A								
	Ring loss	mg	<120	<120	<120	<120	ISO 20763	D7043
	Vane loss	mg	<30	<30	<30	<30		

$9,000 and 12 gallons of sample per grade (all-in cost w/o support)

Functional can support testing

HF Package Versatility

- HF packages are often suitable for use in many other multi-functional products including:
  - Air compressor oil
  - Spindle oil
  - Turbine oil
  - Bearing oil
  - Circulating fluids

Air Compressor

- Compressed fluid applications – HF and air compressor
  - Air compress runs hotter, no cooling medium

- Base fluids:
  - Mineral oil
  - PAO
  - Polyol ester / diester
  - PAG

- Specialty air compressor:
  - Compressed gases other than air
  - Refrigeration
  - Food grade / H1
  - Marine
  - Automotive (turbo compressor)