FUNCTIONAL PRODUCTS INC.
Innovative Chemistry for Lubricants

www.functionalproducts.com

Cost Effective Formulating with Functional Products

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Functional Products Inc.

74th Annual STLE Meeting – Nashville
Commercial Marketing Forum I
9:30 AM, Monday 20th 2019

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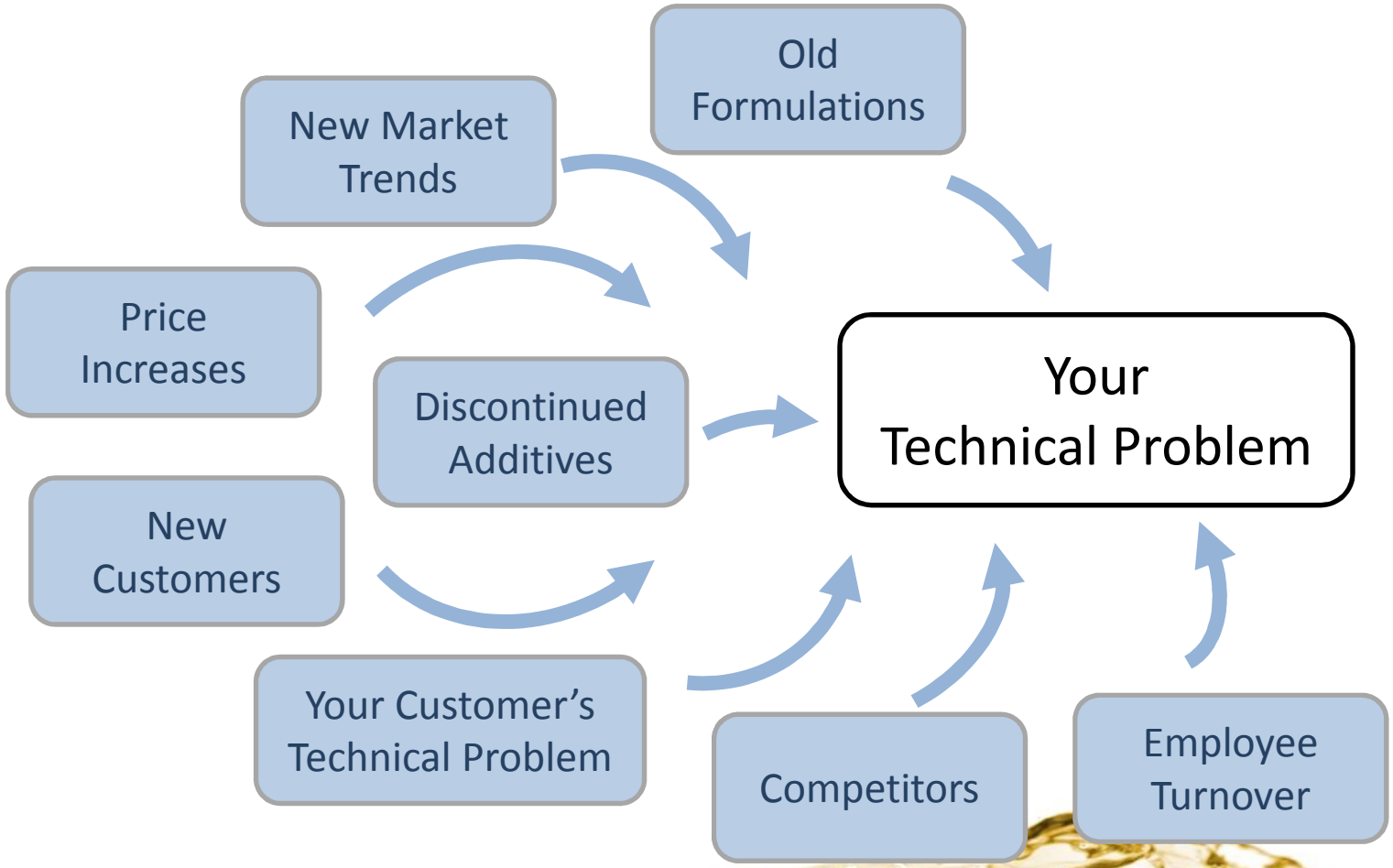
Formulator's Dilemma



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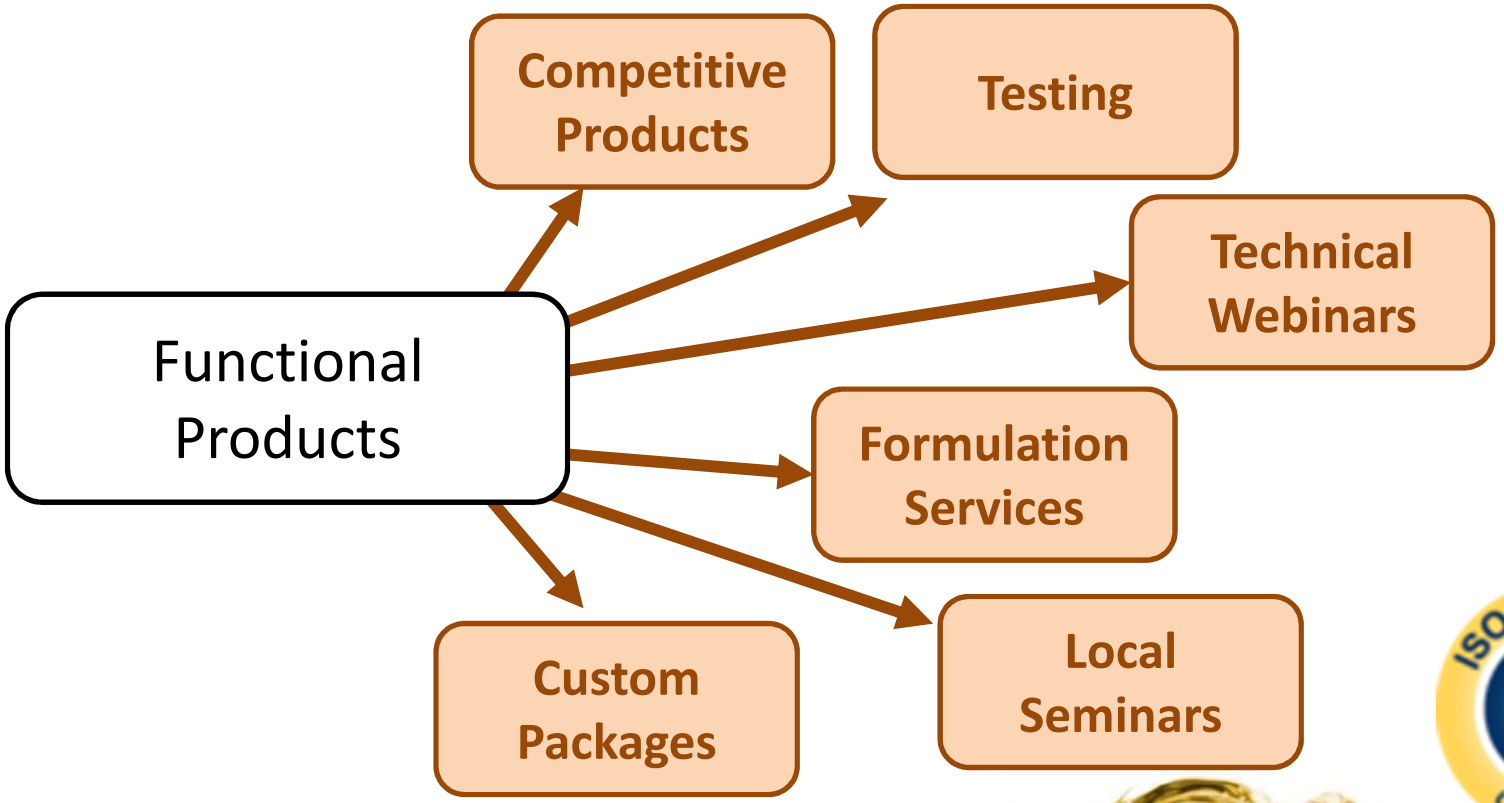
Formulating with Functional

Let us do the search so you can do the research.



ISO 9001:2015 CERTIFIED SMITHERS QUALITY ASSESSMENTS w/ Design

Outline

Achieving formulation goals with lower cost:

- Naphthenic/OCP for high viscosity and low temperature
- Semi-Bio Approach
  - Bar&Chain
  - Hydraulics

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Naphthenic OCP VM

Challenge:

Making high viscosity lubricants with good pour point is difficult
High viscosity at 40°C leads to even higher viscosity at low temp.

- Mining, wire rope, rail, wireline, bar & chain, heavy duty

First Approach: Using high viscosity PAO, PAG, or complex ester

Low Cost Approach: Naphthenic OCP viscosity modifier, **Functional V-158FN**

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V-158FN – Naphthenic OCP

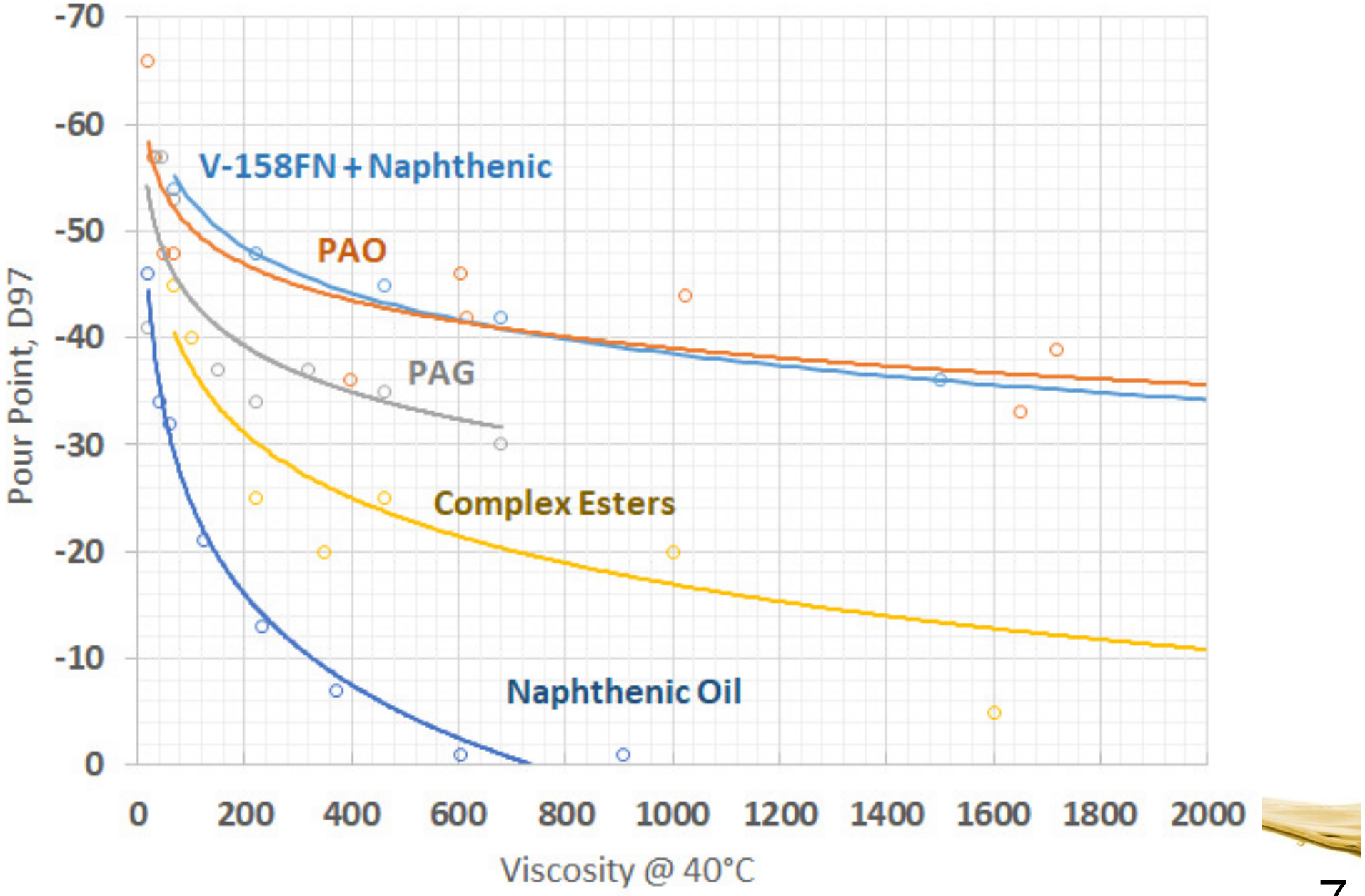
- 2018 paper – low temperature lubricant blending
  - NLGI Development Author Award
    - Olefin Copolymers (OCP) have a stigma as bad for low temp.
      - You just need the right polymer

- We'll compare low viscosity naphthenic oil thickened with V-158FN against:

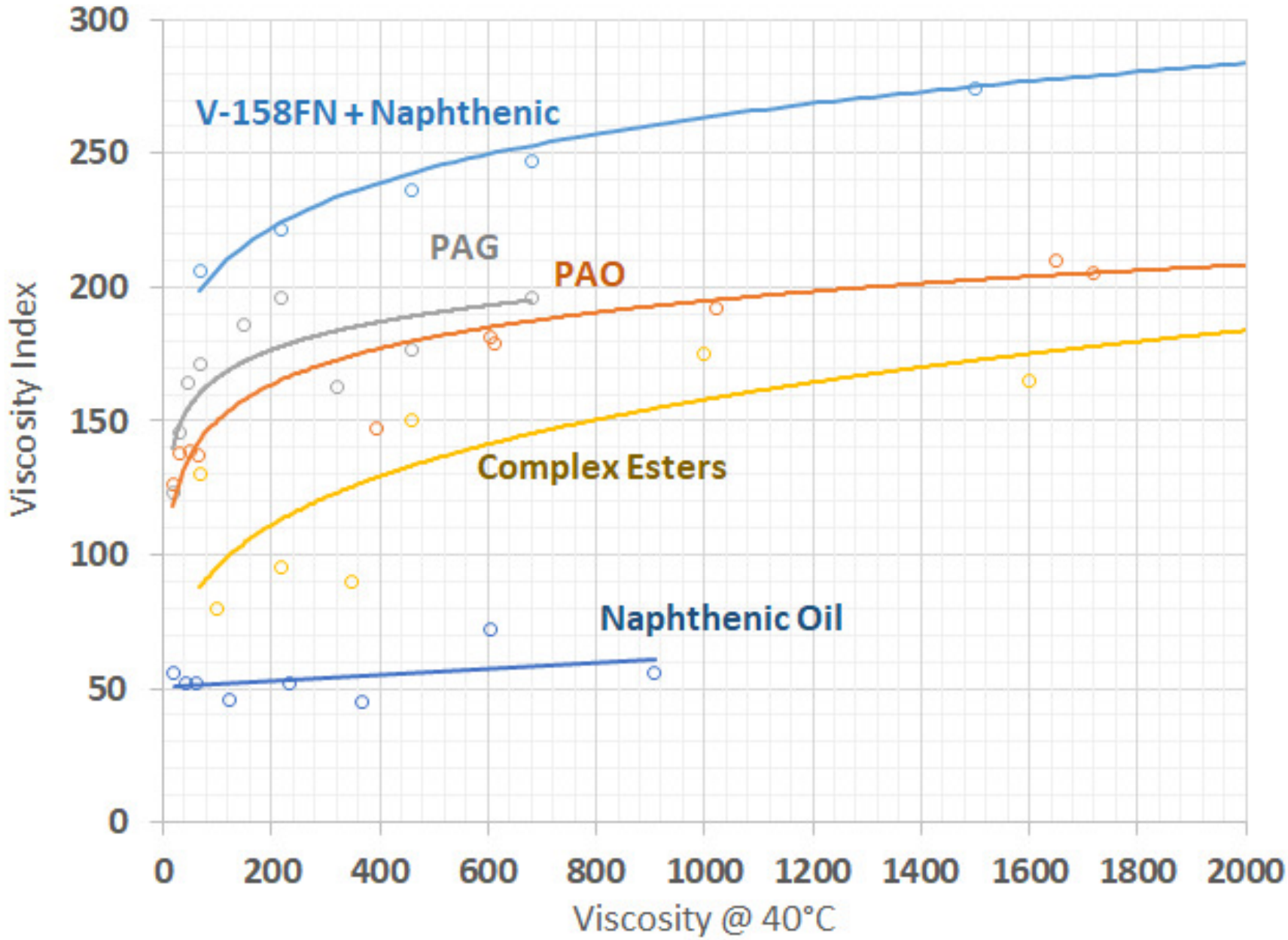
  - Polyalphaolefins (PAO)
  - Oil Soluble Polyalkyeneglycols (PAG)
  - Complex Esters
  - Naphthenic Oils

Willett, E; DeVore, A; Vargo, D. "Investigation of VI Improver Blends for Improved Low Temperature Lubricants" Functional Products Inc. 2018

Competitive Pour Points



Competitive VI



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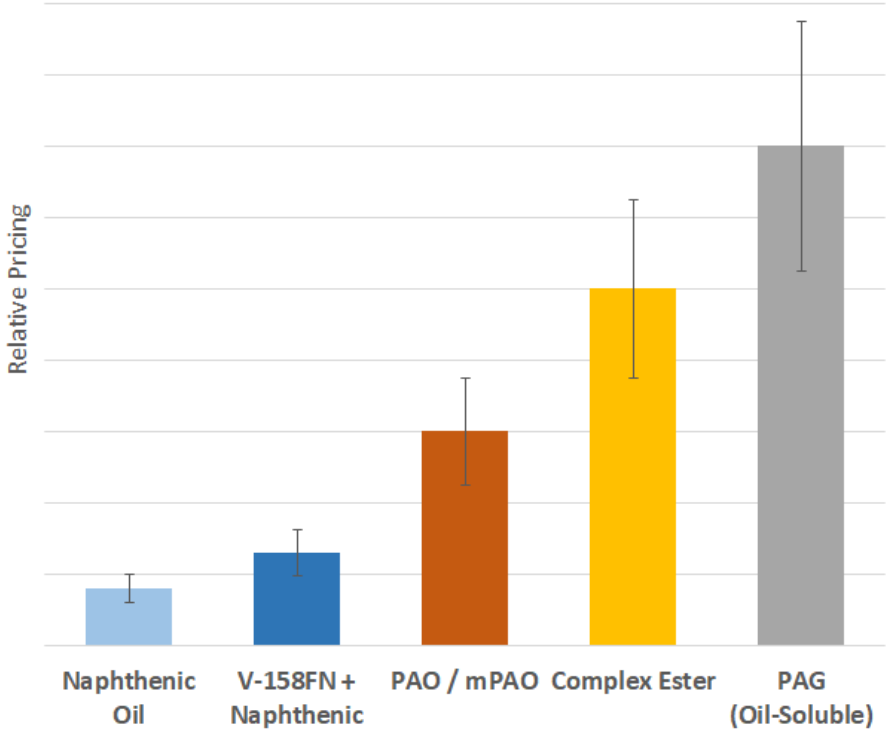
Relative Cost vs. Performance



	$/lb	PP	VI	KV40
Naphthenic Oil	①	⑤	⑤	≤ 1000 cSt
V-158FN + Naphthenic	②	① / ②	①	Any
PAO	③	① / ②	③	≤ 3400 cSt
Complex Ester	④	④	④	Any
PAG (Oil Soluble)	⑤	③	②	≤ 680 cSt

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Example: Wireline

Formula Component by wt%	ISO 68	ISO 220	ISO 460	ISO 680	ISO 1500	ISO 5000	ISO 7500	ISO 10K	ISO 12K	ISO 13K
V-158FN	20.3	34.4	43.3	48.9	60.9	80.1	87	92	95.2	96.6
Additive Package	1.54wt% H2S Corrosion Package or 4wt% EP gear package									
Diluent Oil	0 – 80% 65-100 SUS naphthenic oil									

ISO Viscosity Grade	**ISO 68**	**ISO 220**	**ISO 460**	**ISO 680**	**ISO 1500**	**ISO 5000**	**ISO 7500**	**ISO 10K**	**ISO 12K**	**ISO 13K**
D2270 - Viscosity Index	206	222	236	247	274	318	331	338	342	344
D97 - Pour Point, °C	-54	-48	-45	-42	-36	-27	-24	-24	-24	-24
Pounds / Gallon	7.4 - 7.5	7.4 - 7.5	7.4 - 7.5	7.4 - 7.5	7.4 - 7.5	7.4 - 7.5	7.4 - 7.5	7.4 - 7.5	7.4 - 7.5	7.4 - 7.5
D1500 - Color	Amber < 4.0	Amber < 4.0	Amber < 4.0	Amber < 4.0	Amber < 4.0	Amber < 4.0	Amber < 4.0	Amber < 4.0	Amber < 4.0	Amber < 4.0
D665B - Turbine Oil Rust, Brine	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
D130 - Copper Strip Corrosion	1b	1b	1b	1b	1b	1b	1b	1b	1b	1b
Excellent Demulsibility	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tackiness by Ductless Siphon	Tacky (50-65)	Tacky (50-65)	Tacky (50-65)	Tacky (50-65)	Tacky (50-65)	Tacky (50-65)	Tacky (50-65)	Tacky (50-65)	Tacky (50-65)	Tacky (50-65)
D2596 - EP Weld Load (kgf)	200	200	200	200	250	250	250	250	250	250
w/ EP option	400	400	400	400	400	400	400	400	400	400

ESTIMATED PRICING:

H2S Option (1.54wt% package)										
Rough Cost - $/lb	$0.7	$0.8	$0.9	$1.0	$1.1	$1.2	$1.3	$1.3	$1.4	$1.4
Rough Cost - $/gal	$5.4	$6.3	$6.9	$7.2	$8.0	$9.2	$9.7	$10.0	$10.2	$10.3
EP Option (4.0wt% package)										
Rough Cost - $/lb	$0.8	$0.9	$1.0	$1.0	$1.1	$1.3	$1.3	$1.4	$1.4	$1.4
Rough Cost - $/gal	$5.8	$6.6	$7.2	$7.6	$8.3	$9.5	$10.0	$10.3	$10.5	$10.5

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Semi–Bio Formulations

Challenge:

Biobased bar&chain, hydraulics – customers want more biodegradability than petroleum oil without the added cost

First Approach: Build ISO 32 vegetable oils up to grade using polymer VM

Low Cost Approach: Semi-bio based strategy

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Semi-Bio Bar and Chain

- ISO 100/150/220/etc. bar&chain or saw guide oils
  - Need to bring an ISO 32 vegetable oil up to grade
    - FPI offers **Functional V-515** VM and **Functional V-584** tackifier…
    - But petroleum products simply use base oils and low treat tackifier
      - Let's look at a cost / formulation breakdown

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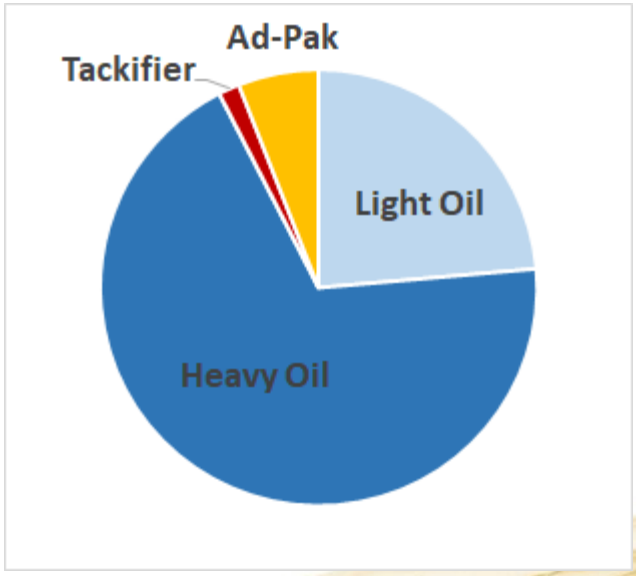
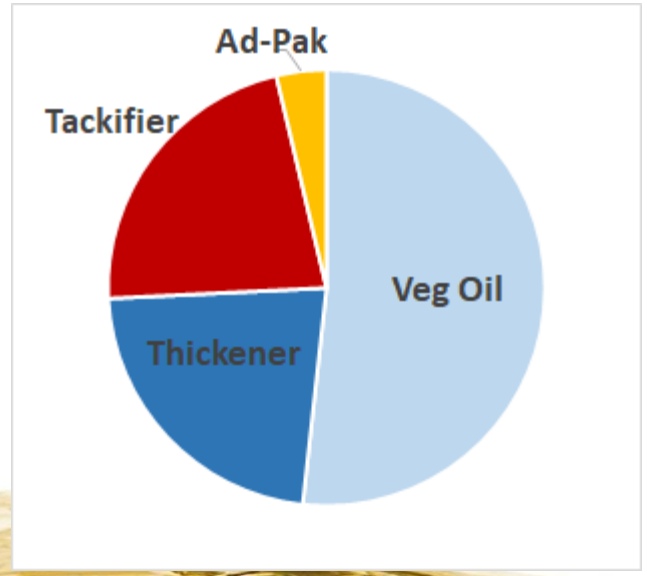
Bar&Chain Economics

	ISO 100 Petroleum B&C Component	wt%	% of cost	ISO 100 Vegetable Oil B&C Component	wt%	% of cost
Base Oil:	300N Gr. II	29.7	23.6	Canola Oil	84	51.7
Thickener:	600N Gr. II	69.3	68.9	Functional V-515	8	22.5
Tackifier:	Functional V-176	0.5	1.6	Functional V-584	7.5	22.1
CI/PPD:	Ad-Pak	0.5	6.0	Ad-Pak	0.5	3.7
		$/lb	$0.50		$/lb	$0.81
		$/gal	$3.67 @ 7.3 lb/gal		$/gal	$6.25 @ 7.7 lb/gal





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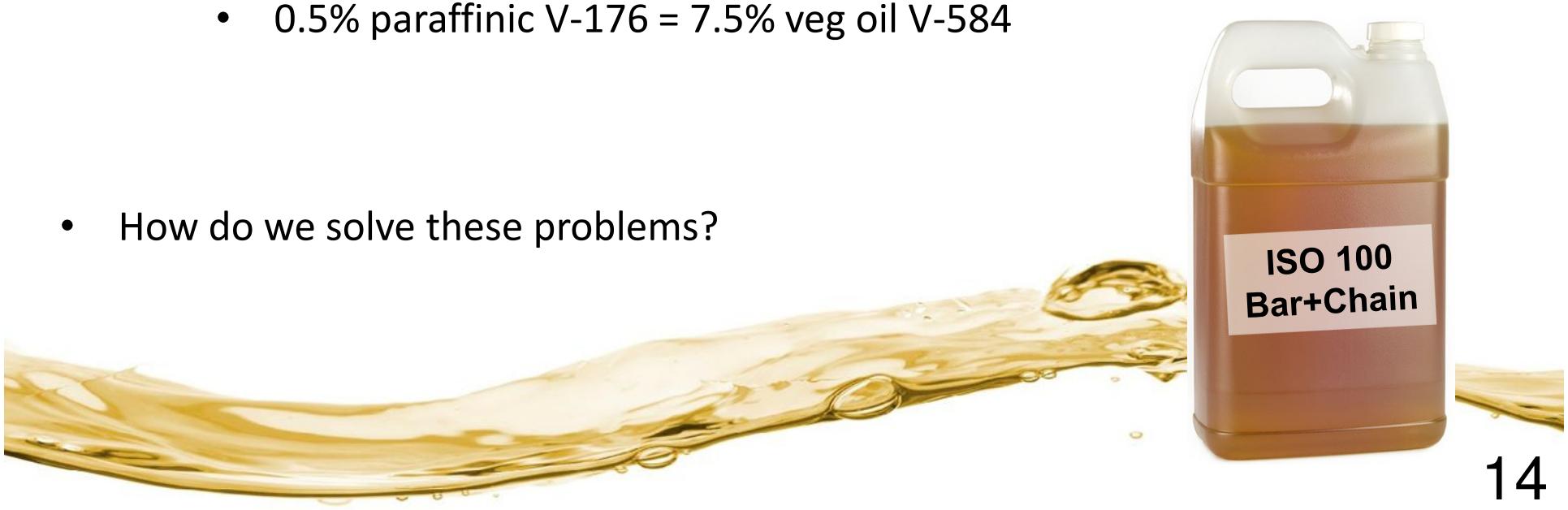
Closer Look at Costs

Canola and other veg oils are not much more than heavy Gr. II paraffinic

- Extra cost is coming from two factors:
  - **High treat of biobased viscosity modifier** to reach ISO 100
    - Light/heavy paraffinic oils priced closely
    - Biobased VM cost is a multiple of veg oil cost
  - **High treat of tackifier** to meet the expected tackiness levels
    - 0.5% paraffinic V-176 = 7.5% veg oil V-584
- How do we solve these problems?



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Semi-Bio B&C

Veg oil formulation is penalized for lack of cheap thickener, must use VM

- What if we try typical paraffinic thickens in canola?
  - Saves 18% cost and reduces use of tackifier

Components:	**ISO 100 Veg**	**ISO 100 w/ BS**	**ISO 100 w/ Gr. II**	% Biodeg.
Canola	84	61	41.3	100
600N			49.7	30
150 Bright Stock		31.6		0
Functional V-515	8	5	6.3	90
Functional V-584	7.5	1.9	2.2	95
Ad-Pak	0.5	0.5	0.5	0
$/lb	$0.81	$0.70	$0.68	
$/gal	$6.25	$5.25	$5.11	
% Bio	98	67	64	

vs. $3.67/gal for petroleum

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Lower Tackifier Treat in Bio

Low treat (0.5 – 1.0wt%) PIB tackifiers will work if % canola < ~50%

- Saves an extra 5% cost

	ISO 100 w/ Gr. II	ISO 100 w/ 176	% Biodeg.
Canola	41.3	43	100
600N	49.7	49.7	30
Functional V-515	6.3	6.3	90
Functional V-584	2.2		95
Functional V-176		0.5	30
Ad-Pak	0.5	0.5	0
$/lb	$0.68	$0.64	
$/gal	$5.11	$4.84	
% Bio	64	64	

vs. $3.67/gal for petroleum

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Semi-Bio Hydraulics

Canola-paraffinic blending can also save cost on biobased hydraulics

- VI 200 HF with 60% biobased content

	Veg Oil w/ PMA			Semi-Bio w/ PMA	
Component	**ISO 32**	**ISO 46**	**ISO 68**	**ISO 32**	**ISO 68**
Canola	97.5	95.1	89.3	60.0	60.0
110N Gr. II	--	--	--	36.5	19.3
600N Gr. II	--	--	--	--	9.7
Functional PD-585	0	2.4	8.2	1.0	8.5
Functional HF-580	2.5	2.5	2.5	2.5	2.5
KV40	36.8	46.1	68.1	31.7	68.3
KV100	8.1	9.9	14.5	7.52	13.5
VI	200	210	225	219	205
p.p.	-24C	-36C	-36C	-39C	-36C
% Biodeg.	97	95	89	71	69
Est. $/lb	$0.71	$0.80	$1.02	$0.71	$1.01
Est. $/gal	$5.50	$6.20	$7.89	$5.29	$7.52
			%Savings:	**3.7%**	**4.6%**
			% Savings if MH-4000 replaces PD-585:	**4.6%**	**10.1%**

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Summary

- Functional Products Inc. for lubricant additives and services

- Low cost strategies
  - Naphthenic + OCP for high viscosity, low temperature at low cost
    - At least 50% less than comparable PAO / PAG / ester

  - Semi-bio bar & chain approach to reduce wt% VM and tackifier
    - 23% savings by using 600N + PIB tackifier

  - Semi-bio hydraulics
    - Up to 10% savings using some mineral oil and mineral oil PMA

More on Tuesday at 9:30AM:
"Evaluation of Water Soluble Polymers for Aqueous Lubricants"
(Section 3K – Environmentally Friendly Fluids I)