Industrial Bar & Chain Overview

June 9th 2021

Overview

- FPI Introduction
- Market Analysis on Bar & Chain Composition/Performance
- Three Bar & Chain Categories
  - Formulation
  - Rough Cost Analysis
  - Performance
  - Use Cases
- Additive Chemistry for Bar & Chain from FPI
- Future Thoughts

Functional Products Inc.’s Position

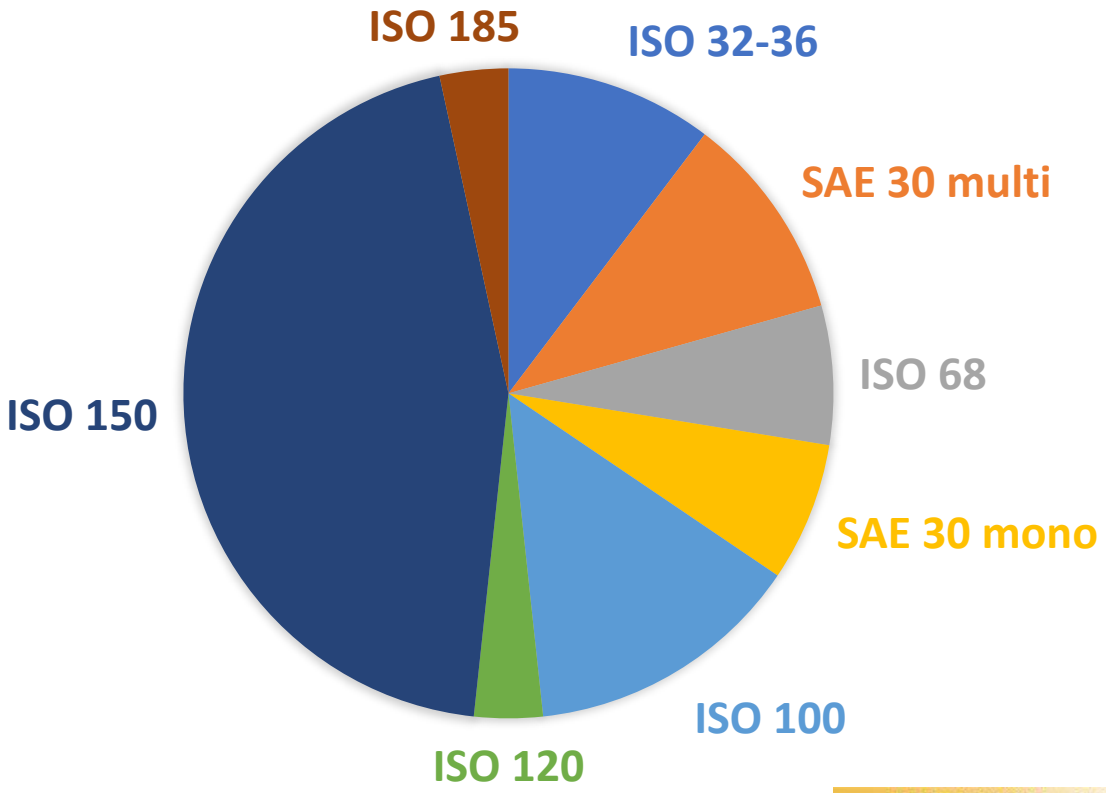
- Science of tack and tacky lubricants
  - Bar & chain
  - Slideway and machine oils
  - Rock drill oils
  - Pneumatic, percussive, and air tool oil
  - Saw guide oils
  - Chain/conveyor lubricants
  - Wireline fluids
  - Textile lubricants
  - Grease

Bar and Chain Market Analysis

Market Analysis – Viscosity Grades

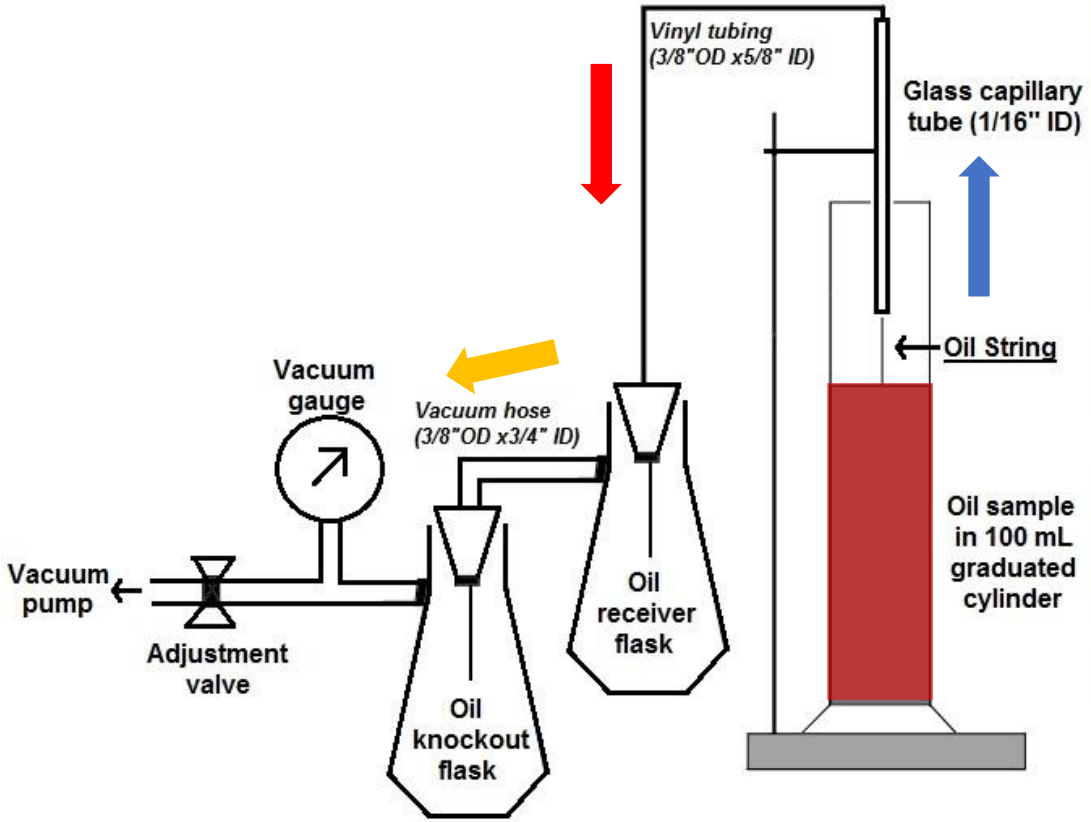
- 29 commercial bar and chain oils evaluated
  - Commercial products exist from ISO 32 up to ISO 185
  - Some OEMs will specify the desired viscosity

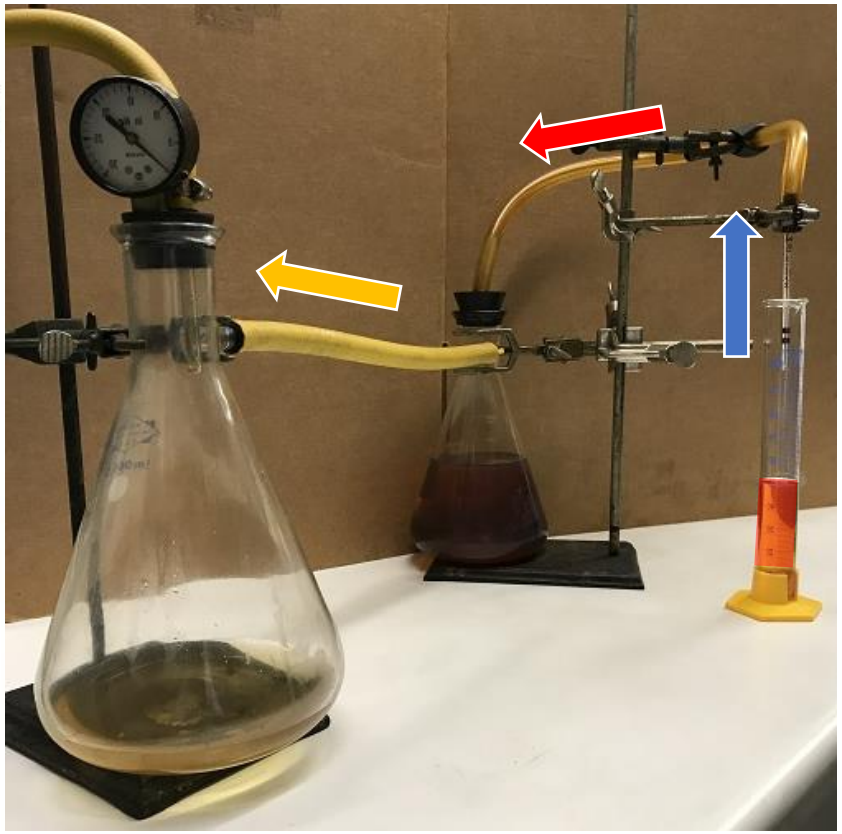
Viscosity Grade	%
ISO 32-36	10.3
SAE 30 multigrade (HVI)	10.3
ISO 68	6.9
SAE 30 monograde	6.9
ISO 100	13.8
ISO 120	3.4
ISO 150	44.8
ISO 185	3.4



Competitively Measuring Tackiness

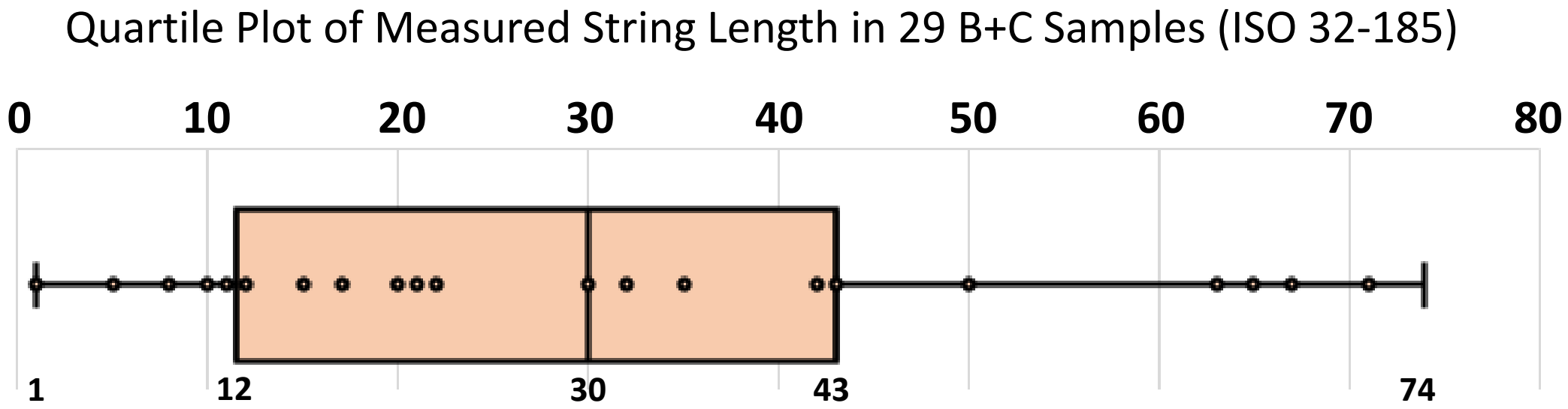
- Functional Products' "ductless siphon" tack tester
  - Pulls oil strings using a vacuum capillary tube until string breaks
  - Report "string length" as length of broken string in graduated cylinder





Market Analysis – Tackiness

- 29 samples evaluated for tackiness (quantified as “string length”)
- 30 – 40 string length on average
- Several major brands on the low end; ILMAs on the mid-high end



Market Analysis – Additive Chemistry

- Additives detected in ~25% of bar and chain oils examined of 29

- When present, typically one or two elements at these levels:
  - ~0.06 +/- 0.05% Sulfur
  - ~0.02 +/- 0.01% Phosphorus
  - ~0.2% Calcium (one case)
  - ~0.02 +/- 0.02% Zinc (two cases)

Market Analysis – Pour Point and Seasonal Grades

- 14 samples examined for pour point

- -24 or -27C pour point most common (64%)

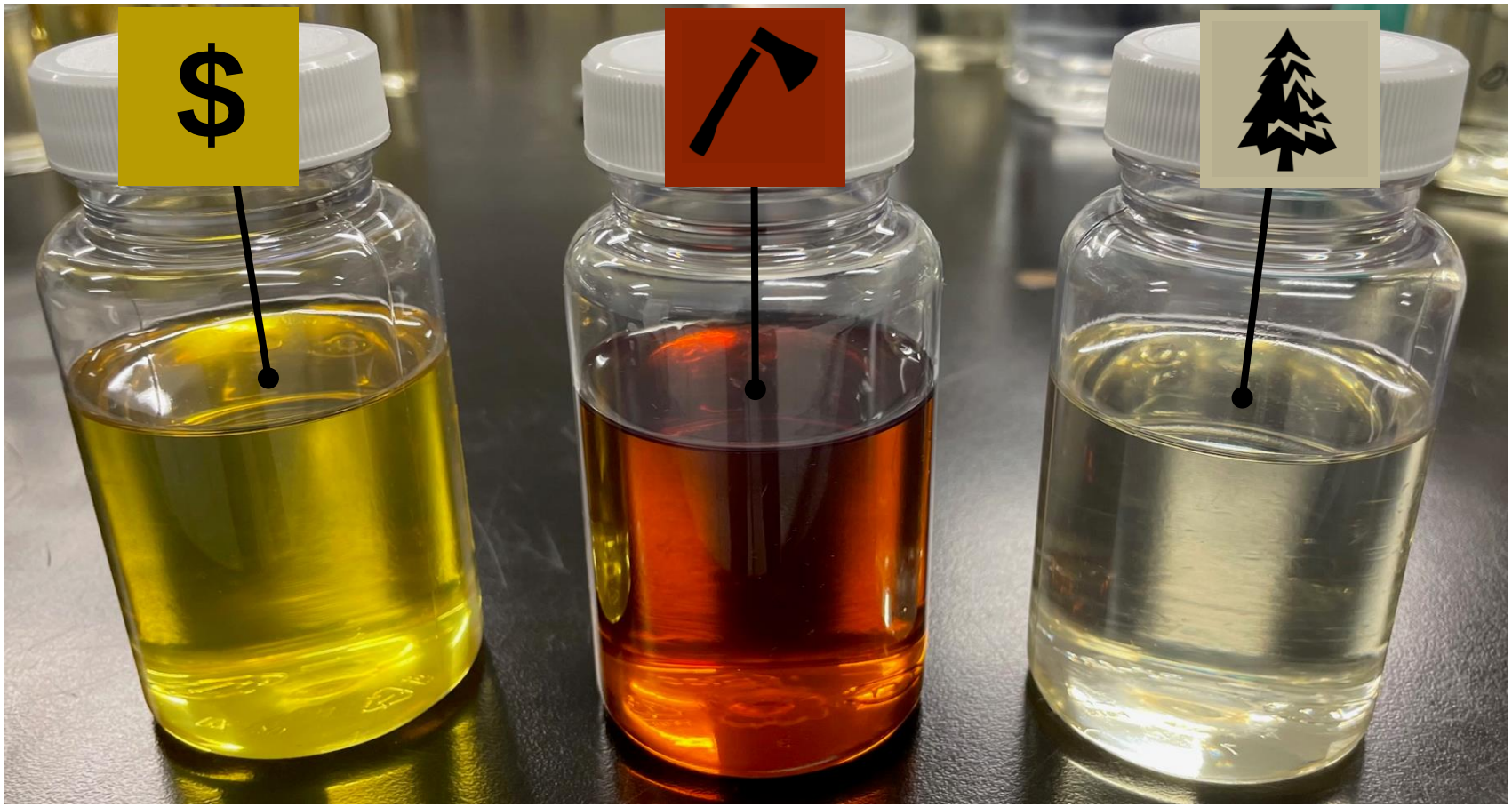
- "Winter" grades (36%)
  - Most commonly at -36C
  - -30C to -39C range

PP, °C	%
-24	35.7
-27	28.6
-30	7.1
-36	21.4
-39	7.1

High VI SAE 30 Bar and Chain Formulating

Three Bar & Chain Categories

“Price-Cutter” “Lumberjack” “Arborist”



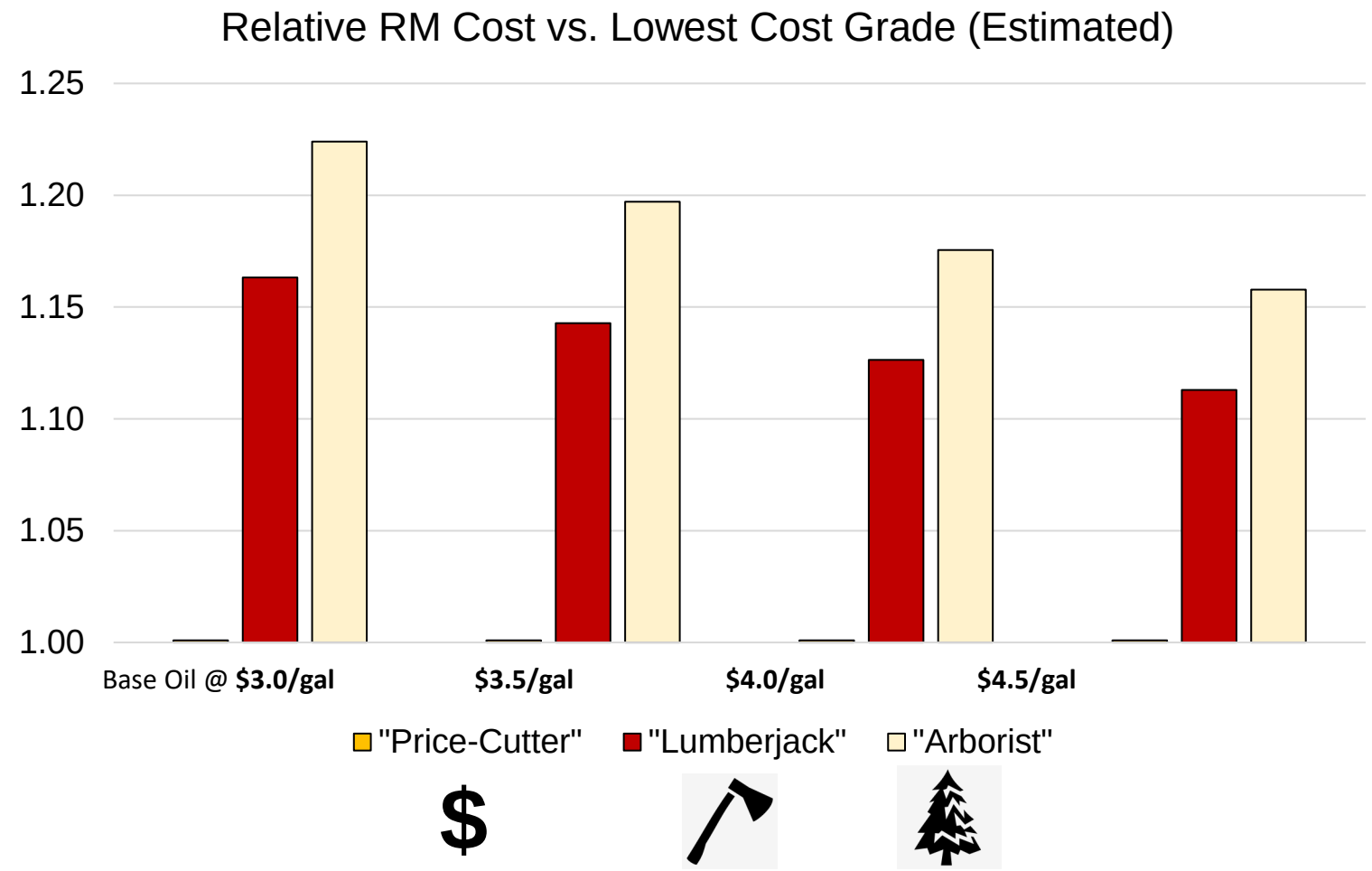
Formulations

Component	"Price-Cutter"	"Lumberjack"	"Arborist"	*Component Role*
5 cSt Oil (VTX6, RHT120)	89.40	87.30	87.20	*Base Oil*
FUNCTIONAL V-158FN	10.60	10.20	--	*Economic VM and Thickener*
FUNCTIONAL V-158F	--	--	9.30	*Workhorse VM and Thickener*
FUNCTIONAL BC-10	--	1.50	--	*Industrial Bar and Chain Ad Pak*
FUNCTIONAL SGP-563	--	--	1.50	*Ecolabel-listed Forestry Ad Pak*
FUNCTIONAL PD-630	--	--	0.25	*Pour Point Depressant ****
FUNCTIONAL V-176	--	1.00	1.75	*Tackifier*

- Price-Cutter – using inherent tackiness and residual sulfur from VM for performance
- Lumberjack – targeting a mid-tier B&C (vs. competitors “HUSQ” and “STHL”)
- Arborist – targeting a higher end B&C (vs. performance-focused ILMA)

Relative Pricing Between Grades

- Mid tier
  - Adds 10-15% cost
- Top tier
  - Adds 15-25% cost

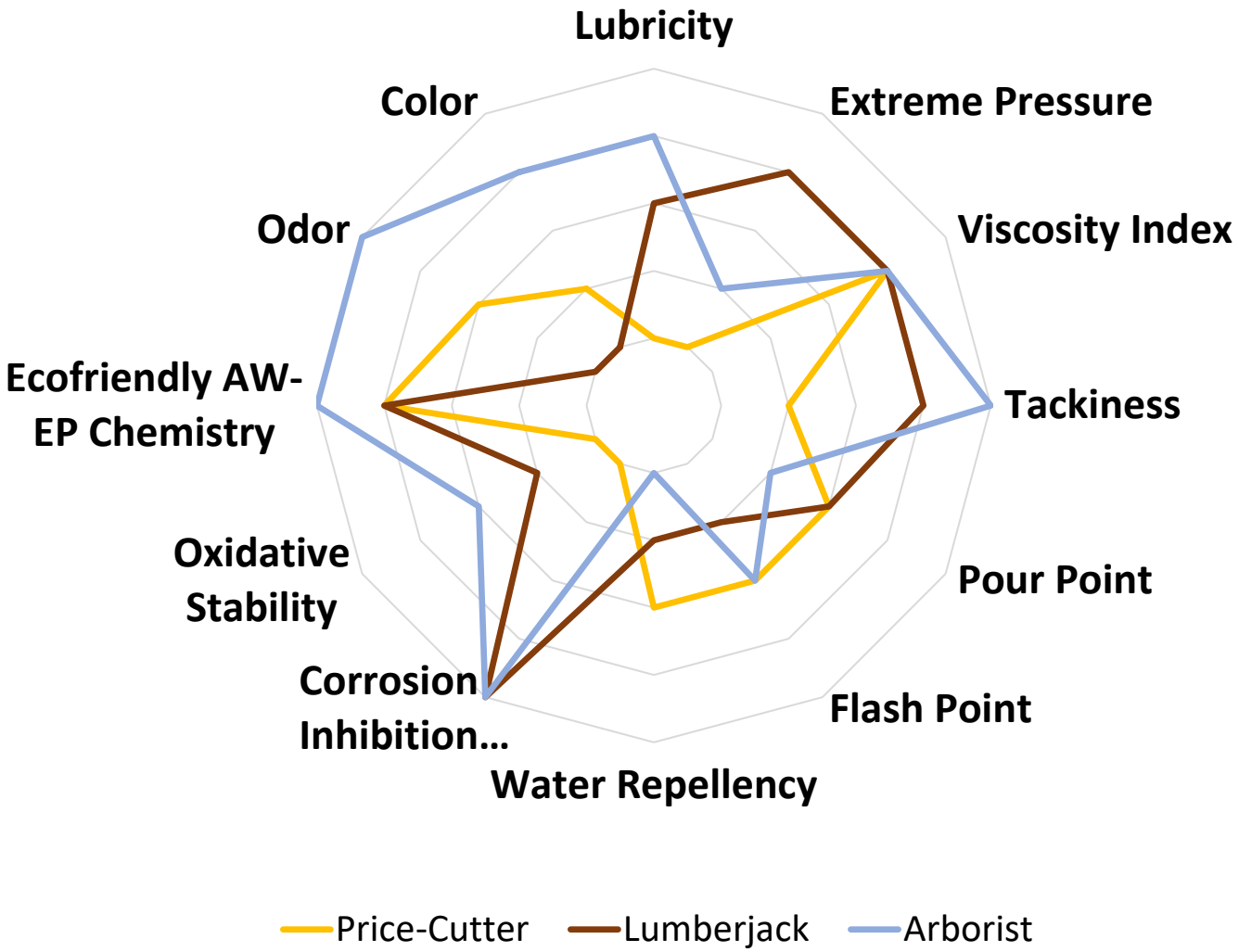


Typical Properties – HVI SAE 30 B&C

Test	Method	"Price-Cutter"	"Lumberjack"	"Arborist"
Kinematic Viscosity @ 100C	D445	10.0	10.1	10.0
Kinematic Viscosity @ 40C	D445	55.2	55.4	56.0
Viscosity Index	D2270	170	172	167
Flash Point, Open Cup, C/F	D92	204C/400F	199C/390F	222C/432F
Pour Point, C/F ***	D97	-21C/-6F	-21C/-6F	-18C/0F
Tackiness (String Length)	FPI DS	5	40	70
Lb/gal Density	D1475	7.11	7.16	7.15
Color	D1500	2.0	4.0	0.5
Odor	Subjective	Petroleum	Sulfur	Slight
Extreme Pressure Weld Load, kgf	D2783	100	200	126
Copper Strip Corrosion, 3hrs 100C	D130	1b	1a	1a
Copper Strip Corrosion, 24hrs 100C	D130	1b/2b	1b	1a
Turbine Oil Rust w/ Distilled Water	D665A	Fail	Pass	Pass
Turbine Oil Rust w/ Synthetic Seawater	D665B	Fail	Pass	Pass
% Sulfur, Typical	XRF	~0	0.10	0.013
% Phosphorus, Typical	XRF	None	0.02	None
% Calcium, Typical	XRF	None	None	0.008

*** Add ~0.25% extra PPD to formula for a Winter Grade version (PP $\leq$ -30C).

Spider Plot Ranking



Performance (5=best)	Price-Cutter	Lumberjack	Arborist
Lubricity	1	3	4
Extreme Pressure	1	4	2
Viscosity Index	4	4	4
Tackiness	2	4	5
Pour Point	3	3	2
Flash Point	3	2	3
Water Repellency	3	2	1
Corrosion Inhibition	1	5	5
Oxidative Stability	1	2	3
Ecofriendly AW-EP Chem.	4	4	5
Odor	3	1	5
Color	2	1	4
Average Score	**2.33**	**2.92**	**3.58**

Based on 1-5 absolute scale covering a wide range of possible industrial and automotive lubricant performance

Who's "Price-Cutter" For?

- Price-based shoppers

- Only use chainsaw a few times a year
  - Don't want to spend more on oil than the saw
  - High rate of tool wear but short use intervals

- Competing with big box store private brands
  - Typically straight oil and no additives; or line wash
  - May or may not contain tackifier

Who's "Lumberjack" For?

- Gas-powered chainsaws to fell trees, mills to process lumber
  - Clearing operations

- Additive chemistry best for shock loading, irregular wear, extreme conditions
  - Hard wood, knots, stumps, foreign material embedded in the wood

- Sulfur-based formula provides best extreme pressure and metal-on-metal protection
  - Would necessitate a uniform and PPE
  - Any residual odor likely secondary to small engine fuel and exhaust

Who's "Arborist" For?

- Mobile electric saws and hedgers to trim greenery or limbs
  - Weekenders, hobbyists, homeowners
  - Professional arborists, yard maintenance, groundskeeping, park services

- Very low color and odor formulation to prevent contaminating clothes and workpieces

- Low friction performance prevents overheat in light weight tools that don't have the mass and surface area to dissipate heat easily

- Active chemistry is European Ecolabel LuSC-listed – safe and non-toxic

Featured Additives from Formulas

FUNCTIONAL V-158F and V-158FN

- 50 SSI liquid OCP viscosity modifiers

- Economical thickeners for industrial lubricant, especially total loss
  - Replace bright stock or synthetic thickeners
  - Lower treat than automotive VMs (25/35/45 SSI)

- V-158F in paraffinic oil
- V-158FN in naphthenic oil, extra cost effective

Alternative Viscosity Grades

- In a 5cSt re-refined Group II (VTX6, RHT120, HCC):

Required Treat to Meet Visc Grade & Viscosity Index

Viscosity Grade	"Price-Cutter"	"Lumberjack"	"Arborist"
ISO 46	8.3% / VI 166	7.8% / VI 166	7.0% / VI 163
SAE 30 Multi. (10 cSt)	10.6% / VI 170	10.2% / VI 172	9.3% / VI 167
ISO 68	13.3% / VI 176	12.9% / VI 176	11.6% / VI 171
SAE 40 Multi. (13 cSt)	14.4% / VI 177	14.1% / VI 177	12.9% / VI 173
ISO 100	18.2% / VI 183	17.9% / VI 183	16.2% / VI 179
SAE 50 Multi. (17 cSt)	18.4% / VI 184	18.1% / VI 184	16.6% / VI 180
ISO 150	23.4% / VI 192	23.2% / VI 191	21.0% / VI 187
	w/ V-158FN	*w/ V-158FN*	*w/ V-158F*

- Cut back with heavy base stocks as desired
- Table also works as guide for other fluids or with different packages

FUNCTIONAL BC-10

- Sulfur-based industrial bar and chain package
  - Emphasis on EP and corrosion inhibition
  - Non-hazardous, biobased sulfur EP

- Developed to compete with major mid-tier bar and chain oils

- Includes cold flow improver to compensate for waxy sulfur
  - Also helpful for the less refined base stocks: Gr. I/II, 150BS, heavy naph.

FUNCTIONAL SGP-563

- European Ecolabel LuSC-listed forestry package for saw and chain
  - Minimal aquatic toxicity, non-bioaccumulative
  - Biobased and biodegradable content

- Calcium based technology to replace zinc or heavy metal chemistries
  - Phosphorus-free for clean waterways

- Minimal color in final product, high oxidative stability for long storage

- Picks up water to prevent settling at bottom of tank or sump

FUNCTIONAL V-176

- Functional Product's main multipurpose tackifier for industrial and automotive lubricants and greases

- 1wt% typical treat rate
  - Tack level will depend on base oil viscosity and type

- In SAE 30 formulations shown, every 1wt% V-176 = 40 string length

FUNCTIONAL PD-630

- Pour point depressant for re-refined Group II/II+ and Group III

- Or use any PPD in house

Future Thoughts

Future Ideas and Gen. 2

- The three basic formulas shown previously are starting points

- Some formulators re-marketing the same bar and chain oil as:
  - Rock drill lubricants
  - Pneumatic/percussive air tools

- Next steps beyond Arborist level:
  - Biodegradable vegetable/petroleum blends (VGP, USDA BioPreferred)
  - Full vegetable bar and chain oil (meeting European Ecolabel)