What about ZDDP?

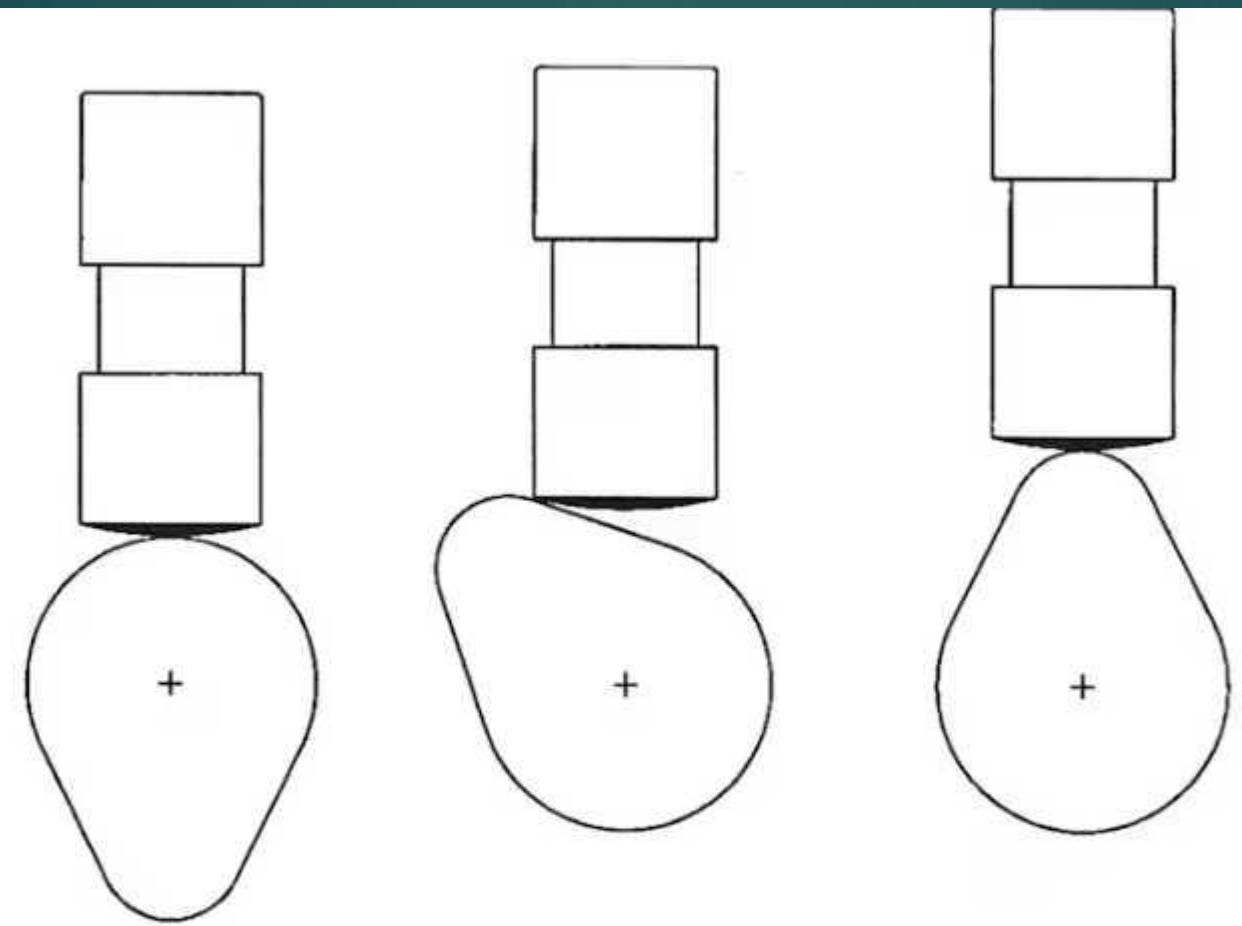
A list of reference articles will be posted on the SBCC.CA website together with this slide set

The problem

- British engines, especially the classic overhead valve engines, use flat tappets with no hydraulic dampening.
- Modern oils may not provide adequate lubrication.

Flat tappets

- Flat tappets are “buckets” that ride on the camshaft lobes
- No hydraulic damping
- Slight convex surface to rotate tappet on camshaft lobe

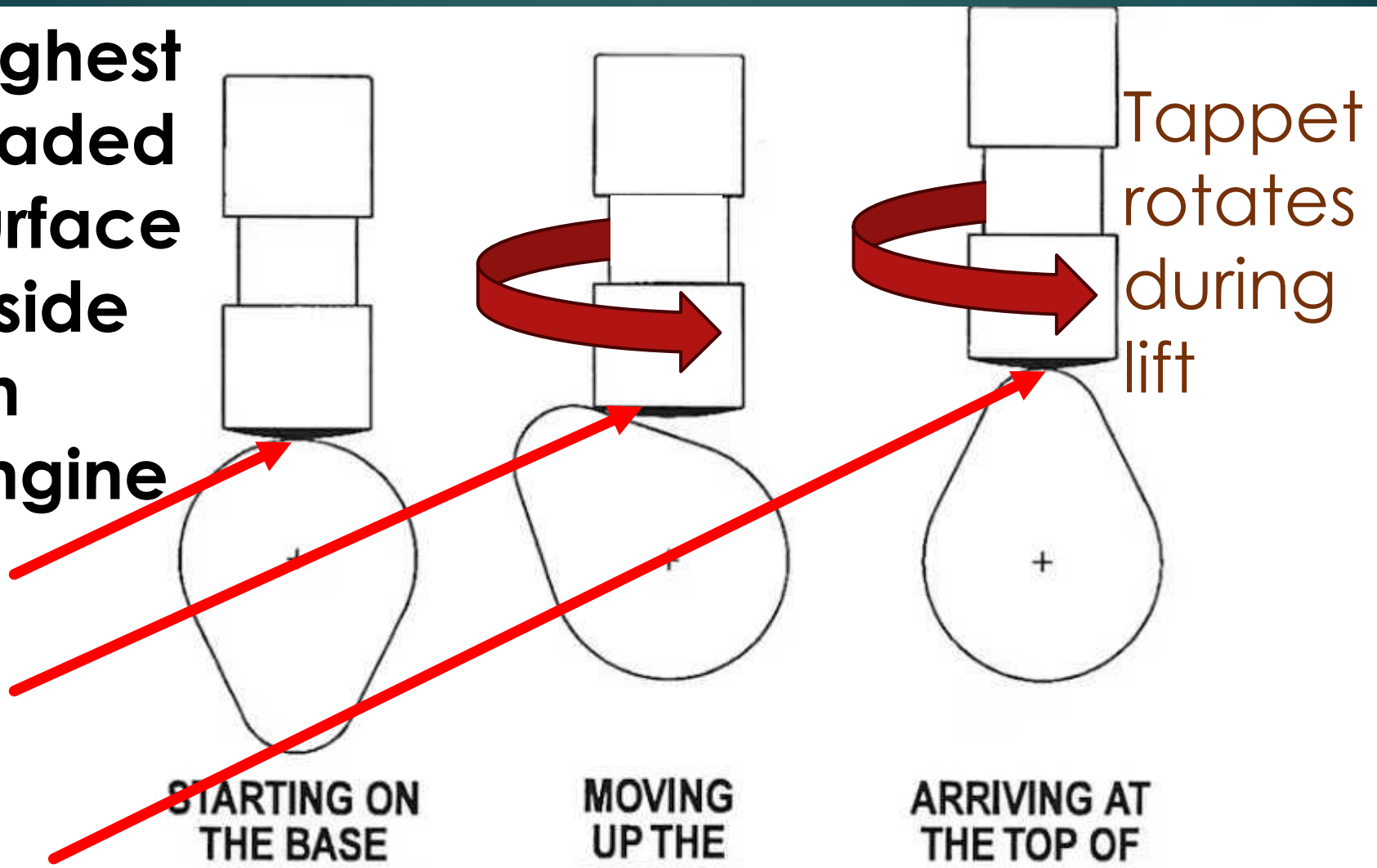


STARTING ON THE BASE CIRCLE OF LOBE

MOVING UP THE OPENING SIDE

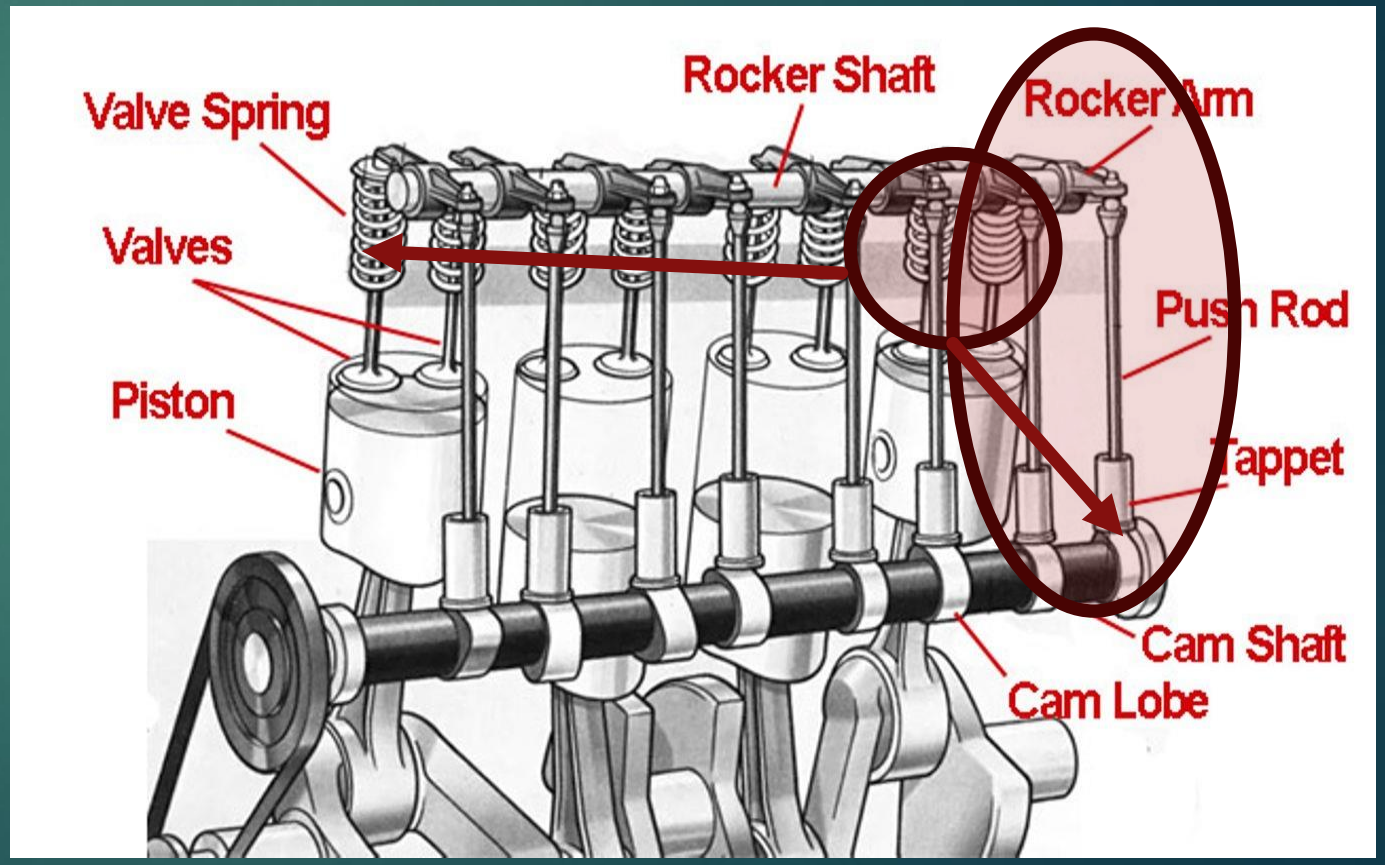
ARRIVING AT THE TOP OF LOBE MAXIMUM LOBE LIFT

Highest loaded surface inside an engine



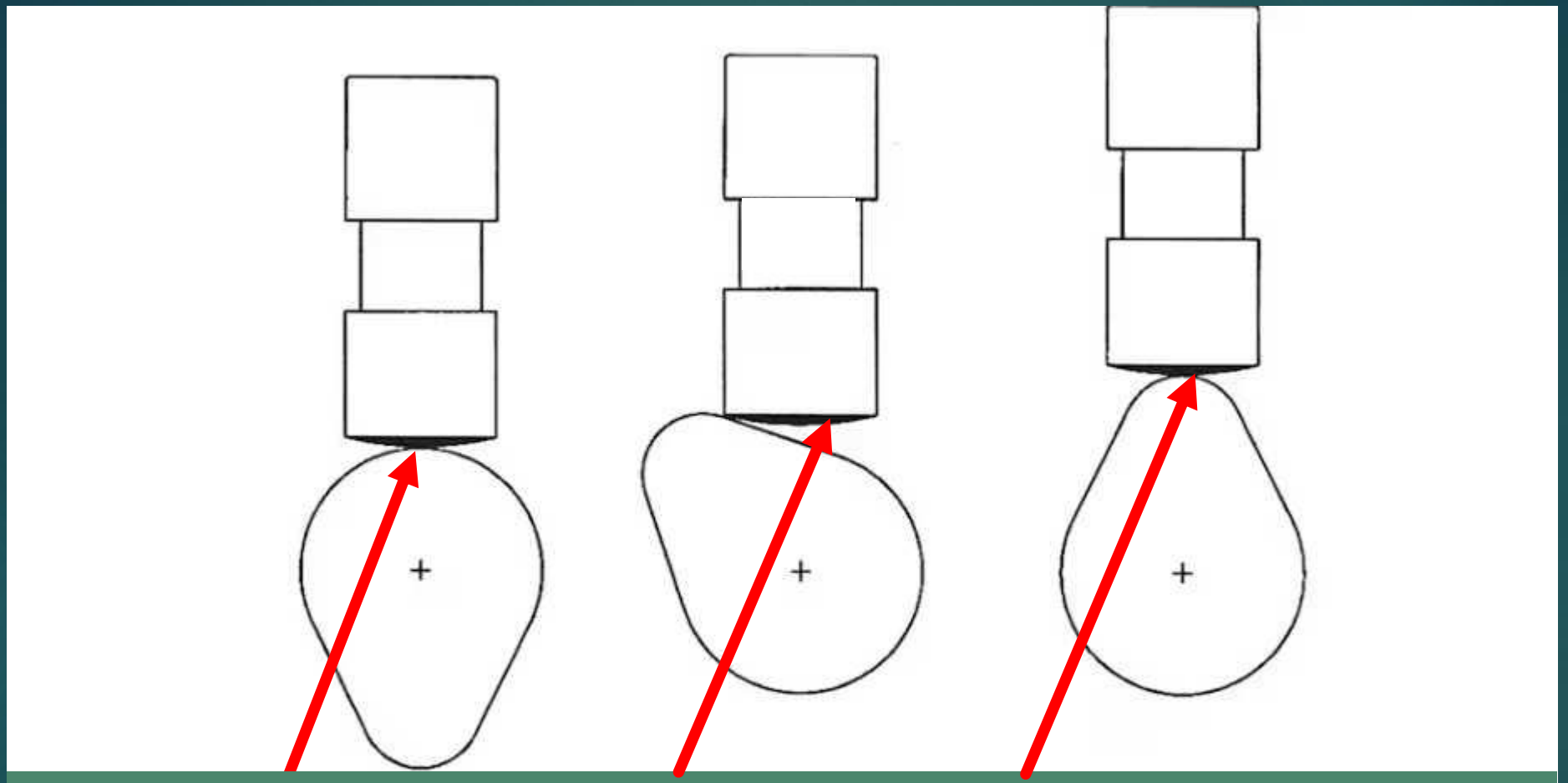
Flat tappets

- Tappets push up on valve rockers through solid pushrods
- No hydraulic damping with solid tappet
- Tappets wipe cam lobes during rotation
- Resistance to tappet movement is increased by strong valve springs



Zinc dialkyl dithiophosphate (ZDDP)

- Zinc and phosphorous major components in compound
- ZDDP added to motor oils since the 1940's
- ZDDP or ZDP still used as an additive to provide several benefits
  - Oxidation stability (oil does not increase in viscosity, acidity prevention)
  - Corrosion inhibition (bearings protected against corrosion)
  - Scuffing and wear protection on extreme pressure surfaces



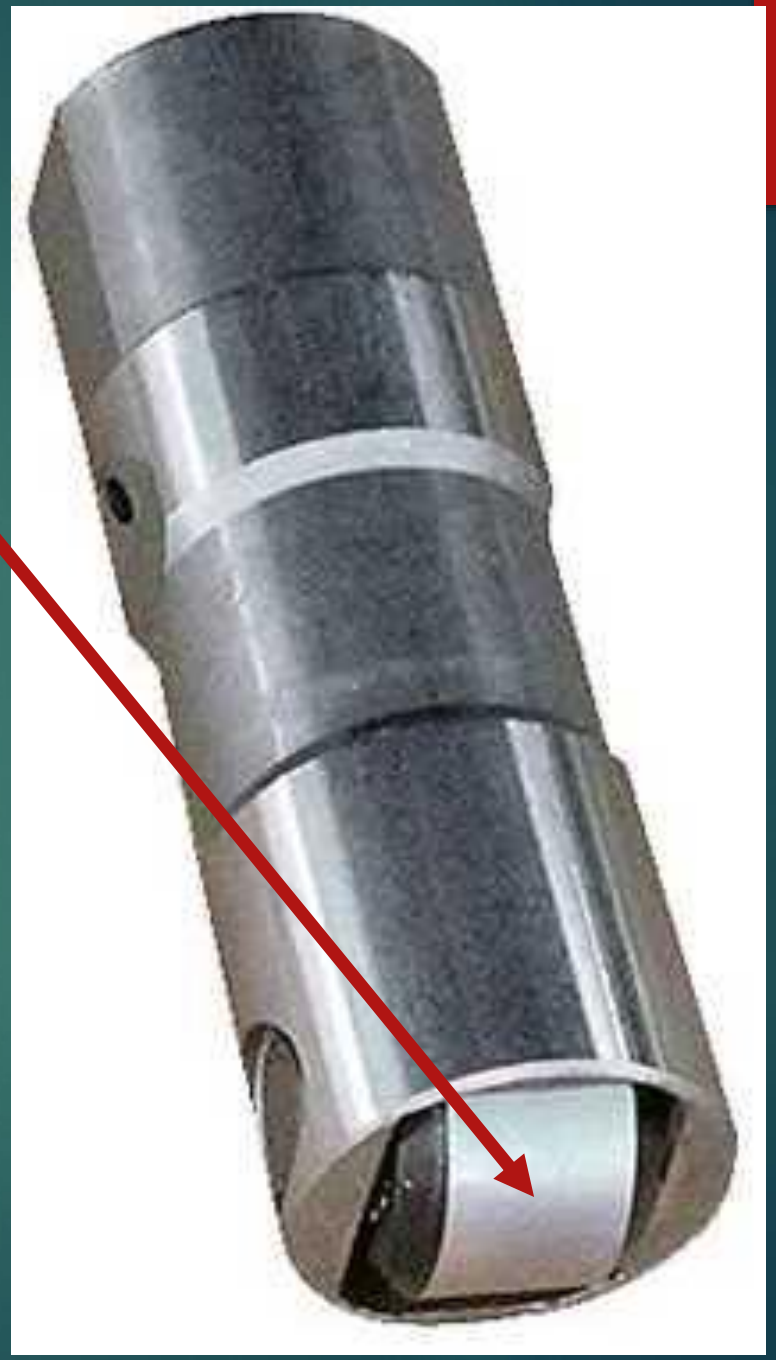
ZDDP degrades and forms a protective film under heat and load conditions

Zinc dialkyl dithiophosphate (ZDDP)

- Phosphorous is toxic to catalytic converters
- Hydraulic roller lifters require less wear protection
- Synthetic oils can be more stable
- Modern additives effective
  - Refiners reduced phosphorous added by ZDDP to 800 ppm or less
  - Moly, boron, titanium, ashless oxidation reducers
- ZDDP has been reduced in modern oils to less than 800 ppm

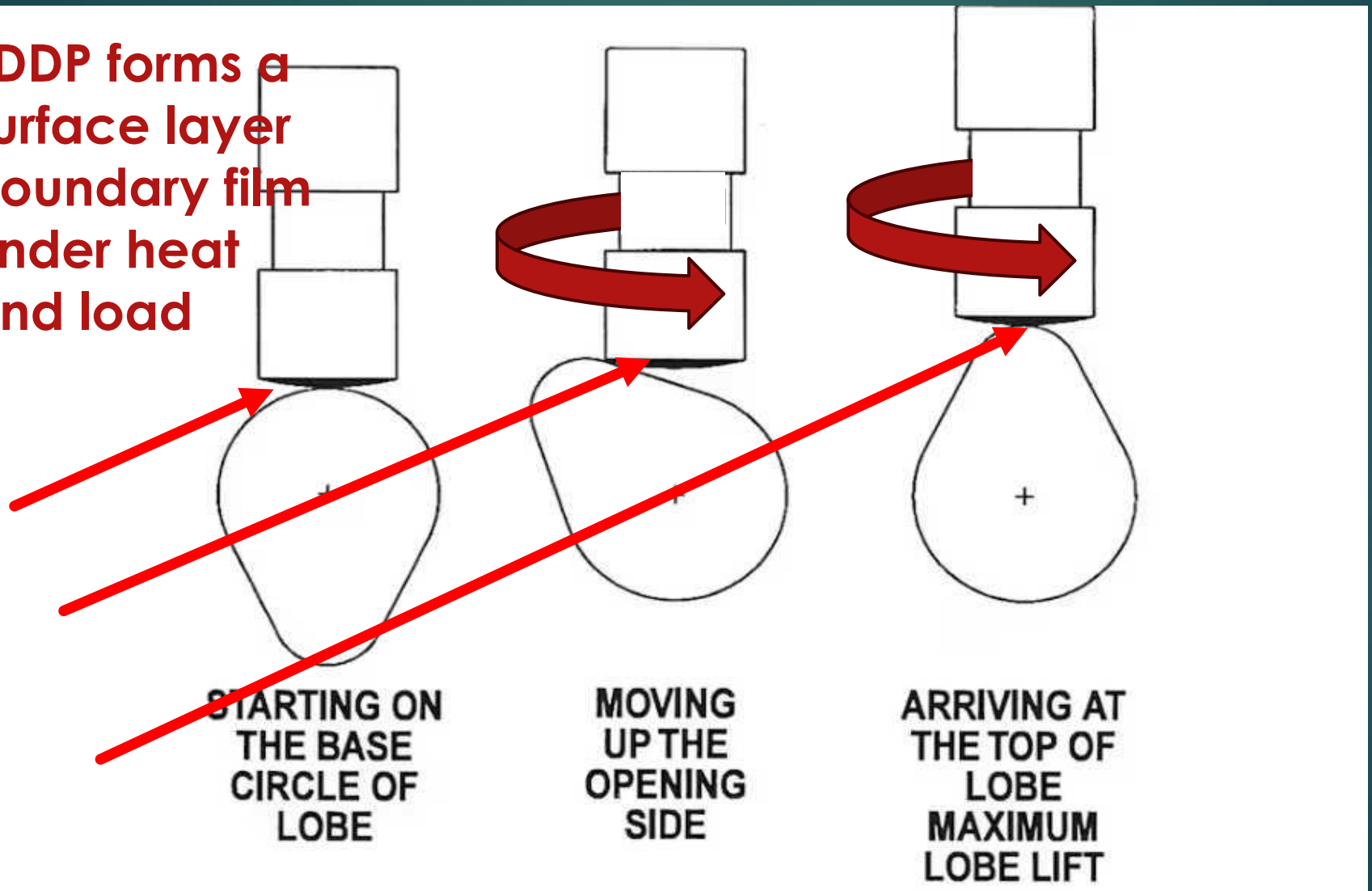
Hydraulic roller lifters

- Roller lifters have less friction where the lifter meets the camshaft
- Hydraulic lifters provide hydraulic dampening to reduce friction
- Lifters often include needle bearings to reduce friction
- Roller lifters do not rotate in the bore



Do we need ZDDP?

ZDDP forms a surface layer boundary film under heat and load



Do we need ZDDP?

- During break-in period
  - Pairs of parts (all components) need to wear into mating shapes
  - ZDDP provides protection for cam and tappet wear during initial startup
  - Assembly lube not adequate for cam protection
- During normal operation
  - ZDDP helpful in reducing wear at camshaft because of extreme pressure
  - Aggressive camshafts and strong doubled valve springs increase pressure
- During long term storage
  - Excess amounts of ZDDP can lead to acidic condition

How is ZDDP measured in engine oils?

- Parts per million (PPM)
  - Phosphorous and Zinc measured separately
  - Oil companies may report ZDDP as a compound average of Zinc and Phosphorous
- Percentage
  - Divide percentage by .0001
  - .24% = 2400 ppm

Castrol GTX Classic 20W50

Typical Characteristics

Name	Method	Units	Castrol GTX Classic 20W-50
Density @ 15C, Relative	ASTM D4052	g/ml	0.87
Viscosity, Kinematic 100C	ASTM D445	mm²/s	18.0
Viscosity, CCS -15C (20W)	ASTM D5293	mPa.s (cP)	8588
Zinc, % wt	ASTM D4951	% wt	0.13
Phosphorus	ASTM D4951	% wt	0.12
Viscosity, Kinematic 40C	ASTM D445	mm²/s	163
Viscosity Index	ASTM D2270	None	123
Pour Point	ASTM D97	°C	-27
Flash Point, PMCC	ASTM D93	°C	210
Ash, Sulphated	ASTM D874	% wt	0.95

Product Performance Claims

API SJ
High Zinc (1400 ppm max)

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Viscosity, Kinematic 100C	ASTM D445	mm²/s	18.0
Viscosity, CCS -15C (20W)	ASTM D5293	mPa.s (cP)	8588
Zinc, % wt	ASTM D4951	% wt	0.13 → 1300 ppm
Phosphorus	ASTM D4951	% wt	0.12 → 1200 ppm
Viscosity, Kinematic 40C	ASTM D445	mm²/s	163
Viscosity Index	ASTM D2270	None	123
Pour Point	ASTM D97	°C	-27
Flash Point, PMCC	ASTM D93	°C	210

How to get ZDDP into your oil

- Consider your engine and driving
  - Break-in
  - Normal driving
  - Storage
- Buy an engine oil with ZDDP included in the blend
  - Research engine oils
  - Look for minimum 1200 ppm
  - Oil specs change frequently

Valvoline VR1 Racing Oil

SAFETY DATA SHEET

Valvoline™ SAE 20W-50 Racing Oil

Valvoline™ Global

Version: 4.0 Revision Date: 07/27/2023 Print Date: 08/10/2023

Zinc O,O,O',O'-tetrakis(1,3-dimethylbutyl) bis(phosphorodithioate	zinc O,O,O',O'-tetrakis(1,3-dimethylbutyl) bis(phosphorodithioate)	2215-35-2	>= 1 - < 5 *

* Actual concentration or concentration range is withheld as a trade secret

Collector's Choice

Typical Physical Characteristics

Product Code	88171	88121	88111	88191
SAE Viscosity Grade	30	10W-30	10W-40	20W-50
API Gravity	29.0	30.5	30.0	29.0
Viscosity, 40 C, cSt	100	70	90	190
Viscosity, 100 C, cSt	11	10.5	13	19
Viscosity Index	105	140	150	120
Wt% Ca	0.24	0.24	0.24	[illegible]
Wt% Zn	[illegible]	[illegible]	[illegible]	0.2
Wt% P	[illegible]	[illegible]	[illegible]	0.09

HR1 Driven Racing Oil

Enhanced ZDDP

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Lucas High Performance 20W-50

TEST	ASTM	TYPICAL
API Gravity	D-1298	26.4
Specific Gravity	D-1298	.8961
Density @ 60°F LBS/US Gal	D-1298	7.462
Viscosity @ 40°C cSt	D-445	195.0
Viscosity @ 100°C cSt	D-445	21.5
Viscosity Index		132
Color	D-92	Clear Brown
Flash Point, COC °F		450
Zinc (Wt. %)		.11

Lucas Hot Rod & Classic 20W-50

HOT ROD & CLASSIC CAR HIGH PERFORMANCE MOTOR OIL SAE 20W-50

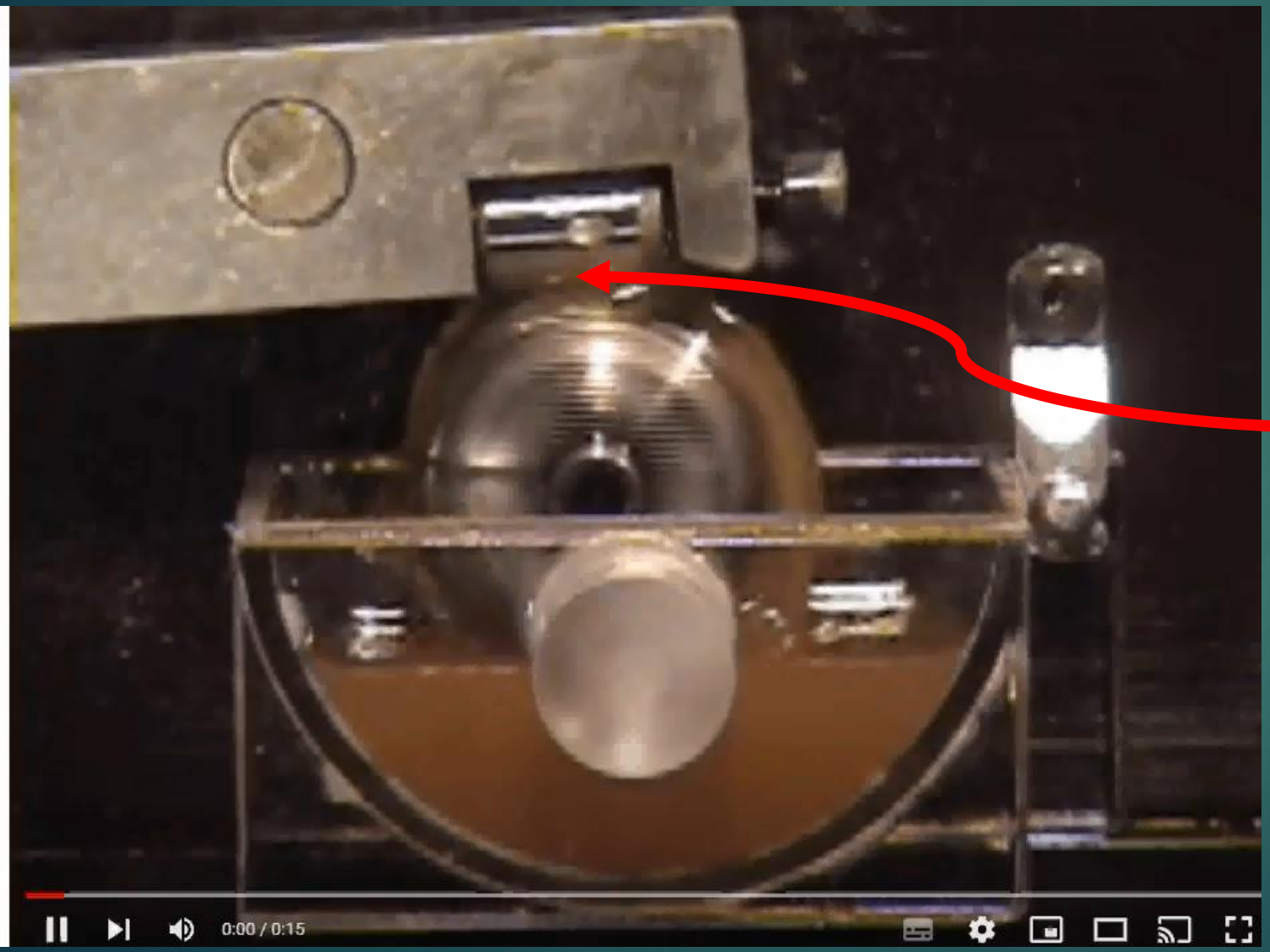
PRODUCT # 10684, 10689

TEST	ASTM	TYPICAL
API Gravity	D-1298	28.0
Specific Gravity @ 60°F	D-1298	0.867
Density @ 60°F LBS/US Gal	D-1298	7.39
Viscosity @ 40°C, cSt	D-445	191.3
Viscosity @ 100°C, cSt	D-445	20.1
Flash Point COC °F	D-92	425
Color		Amber
Viscosity Index	D-2270	122
CCS @ -15°C, CPS	D-5293	9,500 Max
MRV @ -20°C, CPS	D-4684	60,000 Max
Zinc, Wt%	X-Ray	0.21
Phosphorous, Wt%	X-Ray	0.19
TBN Mg KOH/g	D-2896	9.2

Adding a ZDDP supplement

- Dosage problems – how much is too much?
  - Too much ZDDP is harmful
  - ZDDP acidic in nature
  - At .20% phosphorous camshaft may spall
- Adding after refinery blending results in changes to oil chemistry
  - Research shows chemical reactions
  - ZDDP configurations can differ in different oils

Testing a bearing for PSI



- PSI measured by size of scar produced x pounds of force applied
- Smaller the wear scar, the larger the PSI score
- Over 90,000 psi is outstanding

Testing a bearing for PSI

- PSI measured by size of scar produced x pounds of force applied
- Smaller the wear scar, the larger the PSI score
- Over 90,000 psi is outstanding

ZDDP supplements reduce oil effectiveness

- Researcher measured oils by PSI
- *ZDDP reduced protection measured by PSI*
- Royal Purple 20W50 synthetic 83,847 PSI
  - Added ZDDPlus
  - Result was 65,553 PSI – 24% reduction
- Similar results with other oils with ZDDPlus additive

What about ZDDP?

1. **Oil Myths from GM Techlink**

   https://www.nonlintec.com/sprite/oil_myths.pdf

   - ZDP level of new oils is comparable to level found necessary to protect flat-tappet camshafts in the past
   - At about .20% phosphorous, ZDP started attacking the grain boundaries in the iron, resulting in camshaft spalling.

2. **ZDDPlus Oil Additive Dosing and Dilution**

   https://zddplus.com/wp-content/uploads/2017/05/TechBrief7-Oil-Additive-Dosing-and-Dilution-rev4.pdf

   - Very technical paper concerning how correct dosages of ZDDPlus are calculated
   - Target 1800 to 2000 ppm range for phosphorous is designed to give the longest possible anti-wear agent service with no risk of overdosing.
   - This range of phosphorous would give a zinc level of about 1900 to 2100 ppm

3. **ZDDP Content Chart – High Zinc Oil List – Brand Breakdown**

   https://www.speedwaymotors.com/the-toolbox/zddp-content-chart-high-zinc-oil-list-brand-breakdown/32479

   - 2022 article
   - Having under 800 part per million (ppm) of zinc and phosphorous would spell complete disaster for a race engine with a flat tappet cam.
   - Always recommend listening to your engine builder and using the oil with ZDDP they recommend
   - ZDDP comparison list of brands

4. **Can I Mix Zinc Additive with Off-the-Shelf Motor Oil to Save Money?**

   https://www.onallcylinders.com/2018/08/10/ask-away-with-jeff-smith-can-i-mix-zinc-additive-with-off-the-shelf-motor-oil-to-save-money/

   - 2018 article
   - If you need oil with extra ZDDP, the best procedure is to use oil that already contains the additive mixed in the proper dosage.
   - Too much ZDDP can do almost as much art than not enough.
   - Mixing an additive into motor oil can cause adverse chemical reactions.

5. **Best Oil for Flat Tappet Cam**

   https://www.speedwaymotors.com/the-toolbox/best-oil-for-flat-tappet-cam/32480

   - 2022 article
   - Be sure the oil contains between 1,200 – 2.400 ppm of zinc at every oil change (flat tappet cam engines).
   - Engine break-in oils & additives (specific for engine break-in) typically have higher ppm levers, but continuous use of more zinc than recommended isn't a good idea.

6. **Motor Oil Engineering Test Data**

   https://540ratblog.wordpress.com

   - 2013 initial article, blog last updated 2023
   - Engineering Test data using PSI (pounds per square inch) on a large number of oils
   - The higher the psi value, the BETTER the wear protection.
   - Adding ZDDPlus significantly reduced this oil's wear prevention capability

7. **Camshaft Break-in Guide – How to Break in That Flat-Tappet Cam**

   https://www.motortrend.com/how-to/ccrp-1108-camshaft-break-in-guide/

   - 2011 article
   - The best solution for breaking in a new flat- tappet camshaft that involves the least risk is to use the specifically blended break-in oils from companies such as Brad Penn, Comp Cams, Edelbrock, Joe Gibbs, Lucas, and Royal Purple. Break-in oils are blended with higher concentrations of ZDDP to accommodate the severe sliding friction present with a new cam and lifters. Since high detergent levels tend to clean the zinc and phosphorous from high-wear surfaces, evidence suggests the ideal blend for a break-in oil is sufficient levels of ZDDP combined with a lower detergent concentration. This allows the zinc and phosphorous to do their job.