To: API Lubricants Group
Cc: Lubricants Group Mailing List
API

BOI/VGRA Task Force Proposal 3 Sequence VH VGRA

On April 4, 2019 the Lubricants Standards Group (LSG) reviewed "*Table F-aa – Groups I, II, III, and IV Viscosity Grade Read-Across: Sequence VH Test Non-Dispersant Viscosity Modifier*".

"*Table F-aa – Groups I, II, III, and IV Viscosity Grade Read-Across: Sequence VH Test Non-Dispersant Viscosity Modifier"* is given below and on the Electronic Ballot Attachment.

Table F-aa – Groups I, II, III, and IV Viscosity Grade Read-Across: Sequence VH Test Non-Dispersant Viscosity Modifier

	Can be "Read-Across" to:															
Test Run On	0W-16	0W-20	0W-30	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	SAE 30	SAE 40	SAE 50
0W-16	NA	---	---	X	---	X	X	---	X	---	X	X	X	X	X	X
0W-20	X	NA	---	X	X	X	X	---	X	---	X	X	X	X	X	X
0W-30	X	X	NA	X	X	X	X	X	X	X	X	X	X	X	X	X
5W-20	---	---	---	NA	---	X	X	---	X	---	X	X	X	X	X	X
5W-30	---	---	---	X	NA	X	X	X	X	---	X	X	X	X	X	X
10W	---	---	---	---	---	NA	---	---	---	---	X	X	X	X	X	X
10W-30	---	---	---	---	---	---	NA	---	X	---	X	X	X	X	X	X
10W-40	---	---	---	---	---	---	X	NA	X	---	X	X	X	X	X	X
15W-40	---	---	---	---	---	---	---	---	NA	---	X	X	X	X	X	X
15W-50	---	---	---	---	---	---	---	---	X	NA	X	X	X	X	X	X
20W	---	---	---	---	---	---	---	---	---	---	NA	X	---	X	X	X
20W-40	---	---	---	---	---	---	---	---	---	---	---	NA	---	---	X	X
20W-50	---	---	---	---	---	---	---	---	---	---	---	---	NA	---	X	X
SAE 30	---	---	---	---	---	---	---	---	---	---	---	---	---	NA	X	X
SAE 40	---	---	---	---	---	---	---	---	---	---	---	---	---	---	NA	X
SAE 50	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	NA

Notes:

1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by the API BOI/VGRA Task Force and API Lubricants Group
2. A dash (---) means that read-across is not permitted; NA = not applicable
3. New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met
4. Tested formulations containing Group V base stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the candidate oil blend for application of viscosity grade read-across

In support of this read across the BOI/VGRA Task Force provided the "Rationale and Data Overview" (Attachment 1, Page 3) and "Additional Information" (Attachment 1, Pages 5-13). The LSG discussed *BOI/VGRA Task Force Proposal 3 Sequence VH VGRA* and the supporting information. Subsequently a Motion was made: "*That the Table in Slide 2 and the Footnotes be Balloted by the Lubricants Group for acceptance into API 1509 Annex F to guide Sequence VH VGRA*". (Attachment 1, page 4)

The Ballot Motion is given below.

Motion

That the Table in Slide 2 and the Footnotes be Balloted by the Lubricants Group for acceptance into API 1509 Annex F to guide Sequence VH VGRA.

- Motion by: Rick Dougherty
- Second by: Eric Kalberer
  - Affirmative=15
  - Negative=0
  - Abstain=0

Motion Passes

Lubricants Group Members should use the API Ballot System to cast their vote and make comments. The Ballot Link is: http://Ballots.api.org. The Lubricants Group Member votes will be counted, and all received comments reviewed and considered before the ballot results are final.

Non-Lubricants Group Members should comment on the Ballot Motion using the Ballot system. The Ballot Link is: http://Ballots.api.org . All comments on the Ballot Motion will be reviewed before the ballot results are final.

This Ballot will close on May 10, 2019. All Votes and/or Comments must be received by that date. If approved the balloted change will be effective as of April 4, 2019.

Attachment 1

BOI/VGRA Task Force Proposal 3

Sequence VH VGRA

Detroit

R. C. Dougherty

April 3, 2019

Sequence VH VGRA Read Table Proposal

Table F-aa – Groups I, II, III, and IV Viscosity Grade Read-Across: Sequence VH Test Non-Dispersant Viscosity Modifier

	Can be "Read-Across" to:															
Test Run On	0W-16	0W-20	0W-30	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	SAE 30	SAE 40	SAE 50
0W-16	NA	---	---	X	---	X	X	---	X	---	X	X	X	X	X	X
0W-20	X	NA	---	X	X	X	X	---	X	---	X	X	X	X	X	X
0W-30	X	X	NA	X	X	X	X	X	X	X	X	X	X	X	X	X
5W-20	---	---	---	NA	---	X	X	---	X	---	X	X	X	X	X	X
5W-30	---	---	---	X	NA	X	X	X	X	---	X	X	X	X	X	X
10W	---	---	---	---	---	NA	---	---	---	---	X	X	X	X	X	X
10W-30	---	---	---	---	---	---	NA	---	X	---	X	X	X	X	X	X
10W-40	---	---	---	---	---	---	X	NA	X	---	X	X	X	X	X	X
15W-40	---	---	---	---	---	---	---	---	NA	---	X	X	X	X	X	X
15W-50	---	---	---	---	---	---	---	---	X	NA	X	X	X	X	X	X
20W	---	---	---	---	---	---	---	---	---	---	NA	X	---	X	X	X
20W-40	---	---	---	---	---	---	---	---	---	---	---	NA	---	---	X	X
20W-50	---	---	---	---	---	---	---	---	---	---	---	---	NA	---	X	X
SAE 30	---	---	---	---	---	---	---	---	---	---	---	---	---	NA	X	X
SAE 40	---	---	---	---	---	---	---	---	---	---	---	---	---	---	NA	X
SAE 50	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	NA

Notes:

1. X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by the API BOI/VGRA Task Force and API Lubricants Group
2. A dash (---) means that read-across is not permitted; NA = not applicable
3. New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met
4. Tested formulations containing Group V base stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the candidate oil blend for application of viscosity grade read-across

Rationale and Data Overview

Statisticians Review of Original Matrix Data

- Average Engine Sludge: Increasing BOV and Decreasing VM treat both beneficial
- Average Piston Varnish, Rocker Cover Sludge: Increasing BOV beneficial

Approach to Creating Read Table

- Decreasing BOV → No Read
- Increasing BOV, Decreasing VM → Read
- Increasing BOV, Increasing VM → Use Statistician's AES model to determine which effect is strongest

5W-30 → 10W-40 (PCMO) and 10W-30 → 15W-40 (HDEO)

- Reads consistent with technical principles for APV, RCS
- Reads exist in API 1509 for Sequence VG
- Increasing BOV and increasing VM – no technical principle application for AES
- Statistical model for AES suggests very slight debit in performance for both cases, ca. 0.1 AES
- Task Force decided to allow reads based on commercial importance and low risk

Motion

That the Table in Slide 2 and the Footnotes be Balloted by the Lubricants Group for acceptance into API 1509 Annex F to guide Sequence VH VGRA

- Motion by: Rick Dougherty
- Second by: Eric Kalberer
  - Affirmative=15
  - Negative=0
  - Abstain=0

Motion Passed

BOI/VGRA Task Force Proposal #3
Sequence VH VGRA

Additional Information

Sequence VH BOI/VGRA Matrix Overview

- 6 stands; 4 laboratories
- 3 base stock slates (Grp I, Grp II, Grp III); 3 additive technologies
- Every stand referenced in TMC 1011 – Precision matrix hinge oil
- Spanned 0W-16 through 20W-50

Testing Matrix

Oil	Lab	Stand	Tech[(1)]	API Grp	Slate	Rel. VM	(Calc)	VI	(D2007)	(D7419)	Grade
1	D	1	1011	III	D	1.0	4.218	123	98.5	98.3	0W-16
1	E	1	1011	III	D	1.0	4.218	123	98.5	98.3	0W-16
1	G	1	1011	III	D	1.0	4.218	123	98.5	98.3	0W-16
1	G	2	1011	III	D	1.0	4.218	123	98.5	98.3	0W-16
1	A	1	1011	III	D	1.0	4.218	123	98.5	98.3	0W-16
1	A	2	1011	III	D	1.0	4.218	123	98.5	98.3	0W-16
2	G	2	436	II	K	1.7	4.223	109	100.0	-	5W-30
3	D	1	436	II	K	1.0	4.223	109	100.0	-	0W/5W-16
4	A	2	436	I	H	1.7	4.861	95	86.8	82.8	10W-30
5	E	1	436	III	D	1.7	4.866	129	100.0	98.2	5W-30
6	A	2	436	I	H	1.0	6.195	98	87.5	83.5	15W-30
7	A	1	436	III	D	1.0	6.203	130	100.0	97.7	5W-30
8	E	1	1009	III	D	1.7	4.223	124	100.0	98.4	0W-20
9	G	1	1009	II	K	1.0	4.223	109	100.0	-	5W-16
10	G	2	1009	II	K	1.0	11.097	108	99.9	99.0	20W-50
11	A	2	1009	I	H	1.7	4.861	95	86.8	82.8	10W-30
12	G	2	1009	III	D	1.0	4.866	129	100.0	98.2	5W-20
13	A	1	1009	II	K	1.7	6.072	109	99.9	-	10W-40
14	G	1	1009	I	H	1.0	6.195	98	87.5	83.5	15W-30
15	D	1	1011	I	H	1.0	4.861	95	86.8	82.8	10W-20
16	A	1	1011	II	K	1.0	4.831	116	100.0	-	5W-20
17	E	1	1011	II	K	1.0	11.097	108	99.9	99.0	20W-50
18	D	1	1011	I	H	1.7	6.195	98	87.5	83.5	15W-40
19	G	1	1011	II	K	1.7	6.072	109	99.9	-	10W-40

Statisticians' Review of Original Data Set

June 22, 2018

Executive Summary

Regression analyses of Sequence VH BOI/VGRA Matrix Data was performed using 2 slightly different models:

- BOV is a statistically significant credit for AES in both models and for RAC and APV50 in one model and directionally a credit in the other.
- Relative VM Treat is a borderline statistically significant debit in both models for AES.
- BS Group / Slate (or Saturates) is not statistically significant in either model for any of the parameters.

BOI/VGRA Task Force accepted as technical principles for the Seq. VH that increasing BOV and decreasing VM concentration are beneficial to performance

MODEL 1

Term	AES		AEV50		RAC		APV50	
	Credit / Debit	p-Value	Credit / Debit	p-Value	Credit / Debit	p-Value	Credit / Debit	p-Value
Lab		0.3311		0.0828		0.0481		0.9736
Stand[Lab]		0.0962		0.6827		0.3716		0.8586
Tech		<.0001		0.0331		<.0001		0.0102
BOV Calc	Credit	0.0208	Debit	0.2588	Credit	0.1677	Credit	0.1033
Relative VM Treat	Debit	0.0928	Debit	0.2647	Debit	0.3729	Debit	0.4084
BS Group / Slate	Mixed	0.7083	Debit	0.7823	Credit	0.3502	Mixed	0.8351

Statistically significant (p-Value ≤ 0.05)
Borderline statistically significant (0.15 > p-Value > 0.05)

MODEL 2

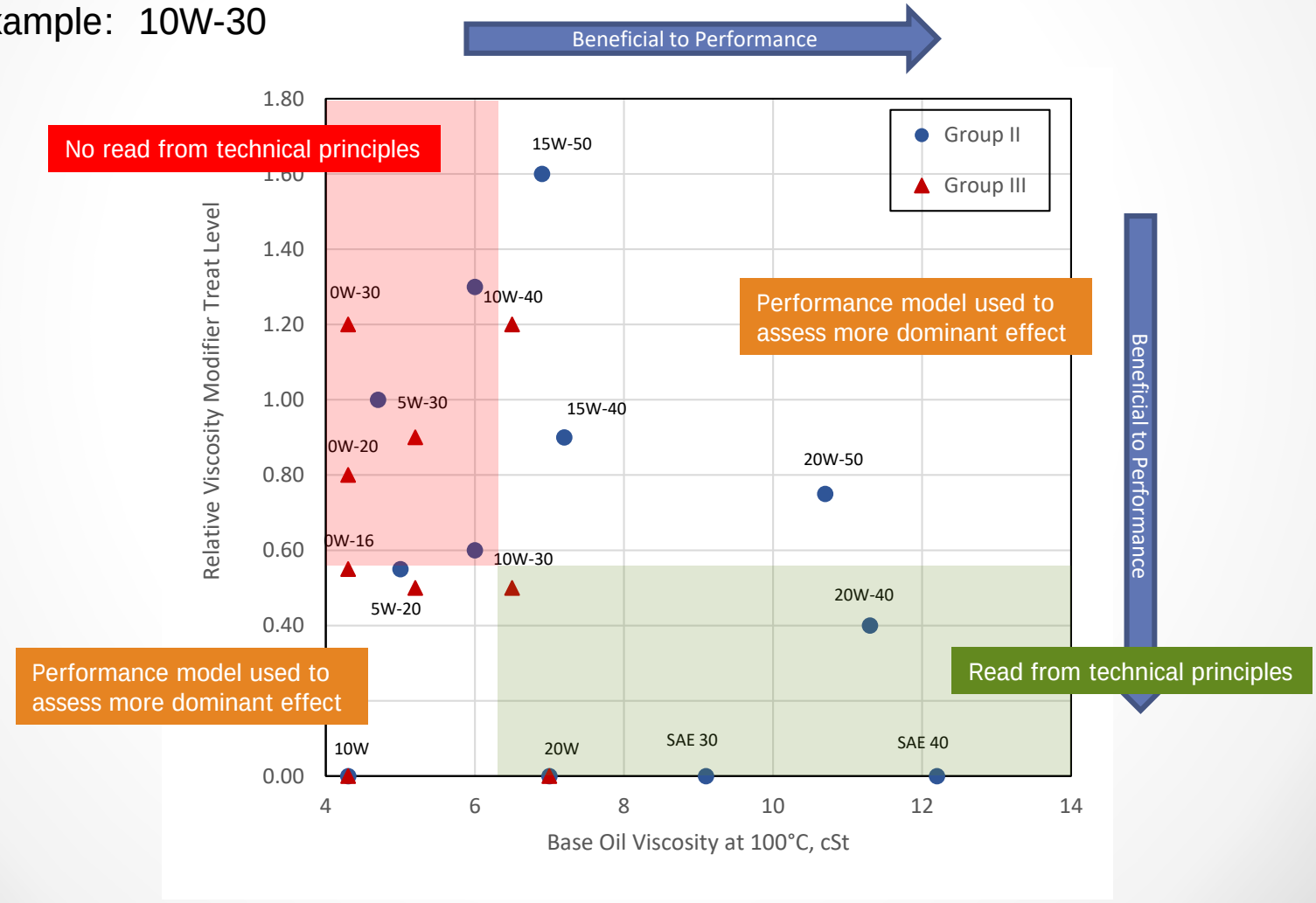
Term	AES		AEV50		RAC		APV50	
	Credit / Debit	p-Value	Credit / Debit	p-Value	Credit / Debit	p-Value	Credit / Debit	p-Value
Lab		0.3085		0.0443		0.0245		0.9417
Stand[Lab]		0.0707		0.6843		0.3934		0.8218
Tech		<.0001		0.0293		<.0001		0.0075
BOV Calc	Credit	0.0048	Debit	0.2020	Credit	0.0477	Credit	0.0256
Relative VM Treat	Debit	0.0636	Debit	0.2565	Debit	0.4061	Debit	0.4279
Sats D7419	Credit	0.3598	Debit	0.5183	Credit	0.2060	Credit	0.6487

Statistically significant (p-Value ≤ 0.05)
Borderline statistically significant (0.15 > p-Value > 0.05)

Considering VGRA Reads: AES

Increasing BOV and Decreasing VM Treat as Technical Principles beneficial to Average Engine Sludge

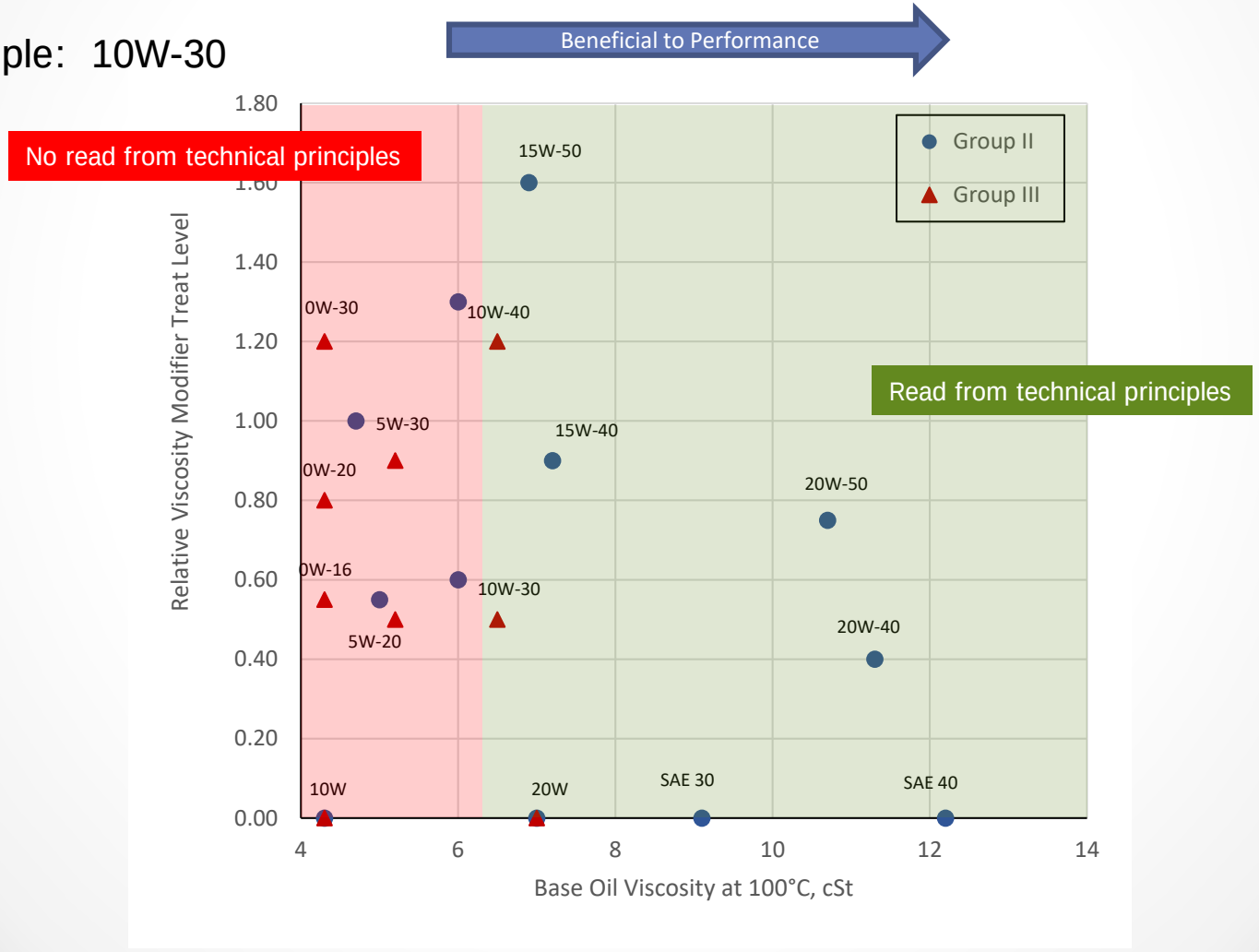
Example: 10W-30



Considering VGRA Reads: APV, RCS

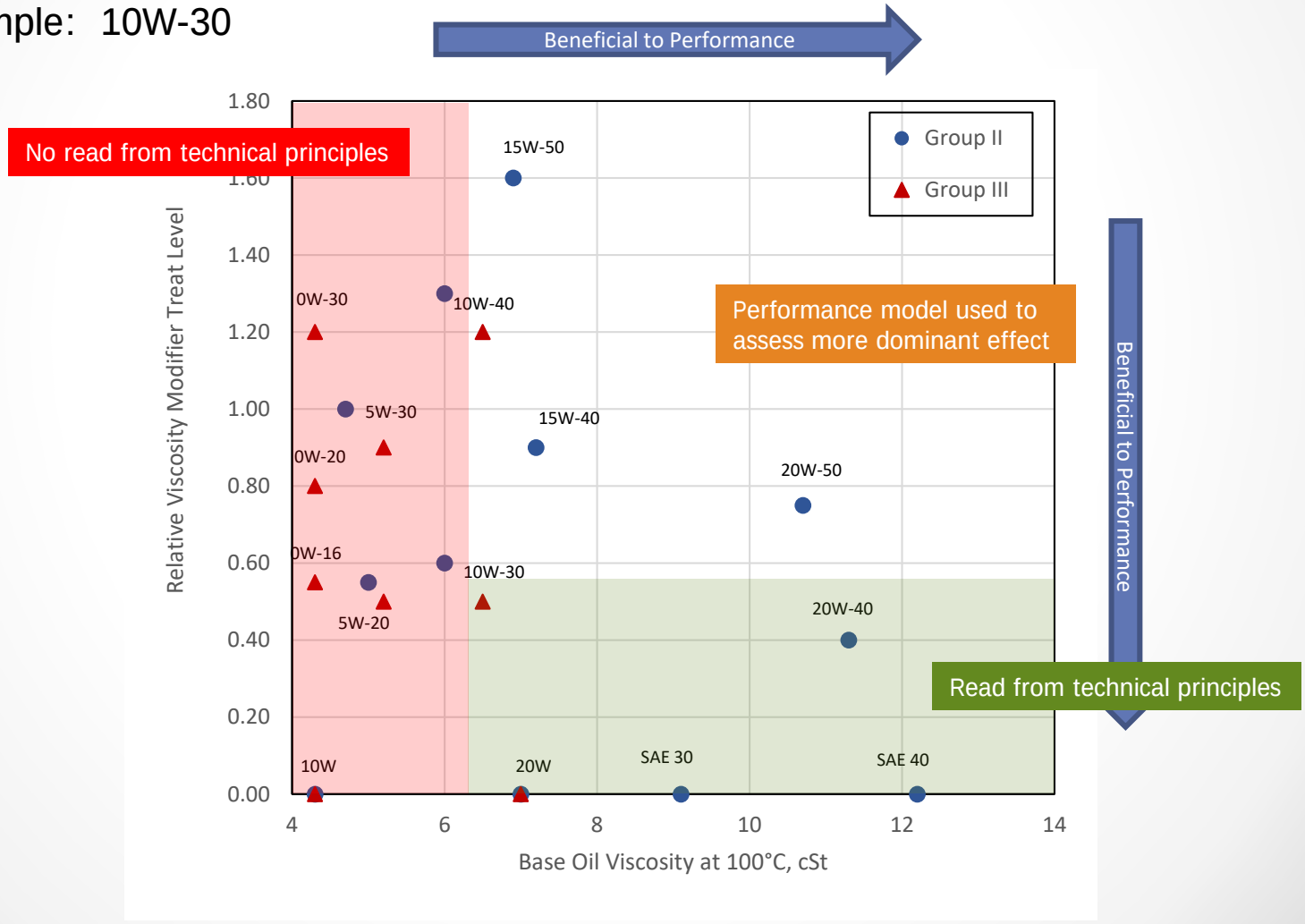
Increasing BOV Technical Principle beneficial to Average Piston Varnish and Rocker Cover Sludge

Example: 10W-30



Basis for VGRA Read Table – All Parameters Considered

Example: 10W-30



Assessing Reads When Technical Principles Not Applicable

Process: Using normalized coefficients, assess whether positive impact of increasing BOV is offset by the negative impact of increasing VM treat on average engine sludge

	Grp II		Grp III		
	BOV	Rel. VM	BOV	Rel. VM	Source
0W-16			4.3	0.55	Afton
0W-20			4.3	0.80	Afton
0W-30			4.3	1.20	Afton
10W	5.8	0	5.8	0	Lubrizol
5W-20	5.0	0.55	5.2	0.50	Afton
5W-30	4.7	1.00	5.2	0.90	Afton
10W-30	6.0	0.60	6.5	0.50	Afton
10W-40	6.0	1.30	6.5	1.20	Afton
20W	7.0	0	7.0	0	Infineum
15W-40	7.2	0.90			Afton
15W-50	6.9	1.60			EM
20W-40	11.3	0.40			Infineum
20W-50	10.7	0.75			EM
SAE 30	9.1	0			Afton
SAE 40	12.2	0			Afton
SAE 50	16.3	0			Afton

From various sources; will be somewhat technology dependent

MODEL 2

Statistician's Model Coefficients for AES
(0W-16 Relative VM = 1.0)

BOV: 0.1429
Rel. VM: -0.5293

Normalized Model Coefficients for AES
(0W-16 Relative VM = 0.55)

BOV: 0.1429
Rel. VM: -0.9624

Calculation Basis

Test Run On	Can be "Read-Across" to: 0W-16	0W-20	0W-30	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	SAE 30	SAE 40
0W-16	Group III applicable								Hybrid Calculation						
0W-20															
0W-30															
5W-20				Group II and Group III applicable											
5W-30															
10W															
10W-30															
10W-40															
15W-40	Hybrid Calculation									Group II applicable					
15W-50															
20W															
20W-40															
20W-50															
SAE 30															
SAE 40															

- Sections where Group II or Group III contributions are considered alone
- One section where Group II and Group III contributions are both calculated; signs for each case match
- Hybrid sections require use of Group II and Group III together; these regions are only practical for Group IV

Calculations only required when BOV is increasing

Calculation Results

- BOI/VGRA Task Force agreed to consider calculations rounded to 1 decimal point as this is how test limits are stated
- Positive values suggest performance improvement (read); Negative values suggest debit (no read)
- Where 2 numbers are shown, calculations made on Group II and Group III bases
- 5W-30 / 10W-40 (PCMO) and 10W-30 / 15W-40 (HDEO) are of high commercial importance; AES model shows extremely small predicted negative impact which RCS/APV technical principles suggest a benefit . . . Task Force agreed to allow reads to higher viscosity grades

	Can be "Read-Across" to:														
Test Run On	0W-16	0W-20	0W-30	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	SAE 30	SAE 40
0W-16	NA				-0.2			-0.3	0.1	-0.6	0.9		0.7		
0W-20		NA			0.0			-0.1	0.3	-0.4	1.2				
0W-30			NA							0.0					
5W-20				NA		0.6 / 0.6	0.1 / 0.2	-0.6 / -0.5	0.0	-0.7			0.6		
5W-30					NA	1.1 / 1.0		-0.1 / -0.1		-0.3					
10W						NA	-0.5 / -0.4	-1.2 / -1.1	-0.7	-1.4		0.4	0.0		
10W-30							NA		-0.1	-0.8			0.5		
10W-40								NA		-0.2					
15W-40									NA						
15W-50										NA					
20W											NA	0.2	-0.2		
20W-40												NA			
20W-50													NA		
SAE 30												-0.1	-0.5	NA	
SAE 40															NA

Read based on technical principles

Read not allowed based on technical principles