



RO-1006 Replacement

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Background

- ▶ TMC Reference Oil 1006 was originally introduced in 1997 as an ILSAC GF-2 category reference oil
- ▶ Two subsequent batches were made to support industry reference testing, RO 1006-1 and RO 1006-2
- ▶ RO 1006 cannot be reblended because the Group I basestock used in the formulation is no longer in production



Current Status

1006-2 Status

- ▶ TMC Inventory of 1006-2 is at 2200 gallons
 - It can not be re-blended
- ▶ 1.5-year usage
 - SF105 345 gallons
 - Specified in ASTM D471 & GM Standards
 - EOEC/LDEOC 461 gallons
 - IVA/VG/VIII 140 gallons
 - Total 946 gallons
- ▶ Estimated Life ~24 months



Current Usage

RO 1006 is used as a reference oil in many tests

- ▲ Heavy Duty Engine Oil Elastomer Compatibility
- ▲ Light Duty Engine Oil Elastomer Compatibility
- ▲ ASTM D471 – Service Liquid 105
- ▲ SAE J2643 – Service Liquid 105
- ▲ ASTM D6891 – Seq IVA
- ▲ ASTM D6593 – Seq VG
- ▲ ASTM D6709 – Seq VIII
- ▲ ASTM D6557 – Ball Rust Test



Overview of Events

- ▲ **Task Force was formed after June ASTM meeting to identify possible replacements for RO 1006-2**
 - ▲ Members include Afton, Chevron, ExxonMobil, Infineum, OHT, SwRI, TMC and Volvo

- ▲ **Input was also solicited from elastomer experts**

- ▲ **Existing alternatives were investigated and rejected**

- ▲ **Several 'Clone' formulations were developed and screened through LDEOEC and HDEOEC**
 - ▲ Additive package is very similar, though not exactly the same
 - ▲ A leading replacement candidate was selected



Summary

Conclusion: everyone is happy with RO 1006

- ▲ Minimize change

Step 1: initial LDEOEC and HDEOEC scoping of RO 1006 Clones

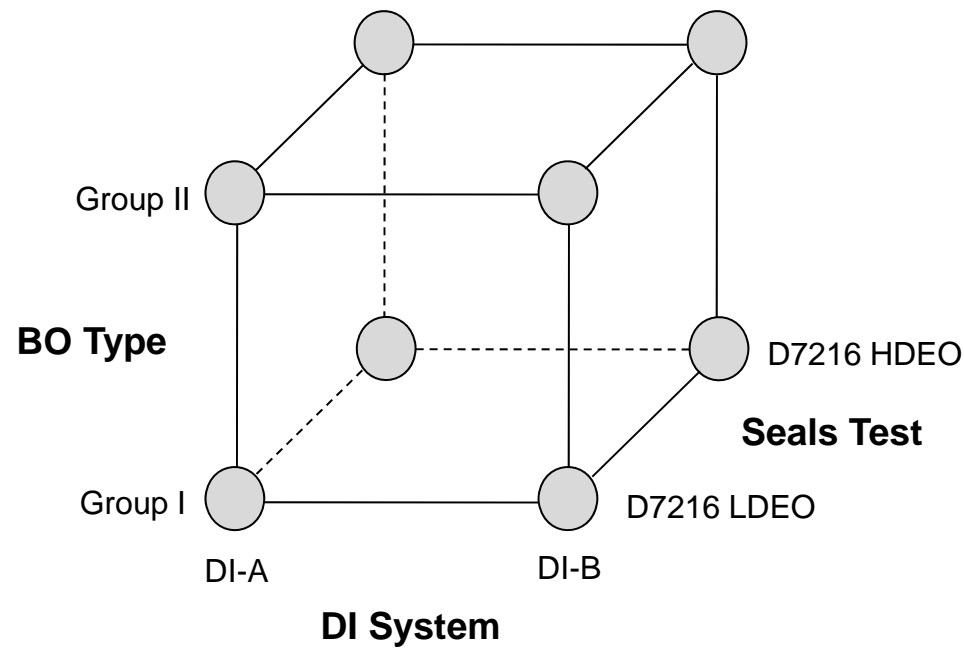
- ▲ Leading option will use common Group II base stock
- ▲ Back-up option will use a similar Group I base stock

Step 2: select best option from Step 1, blend a drum or two for more extensive evaluation

- ▲ Update ASTM classification and surveillance panels to develop further test plans and acceptance
- ▲ Update SAE and OEM / Elastomer stakeholders
- ▲ Scope performance in Seq VIII



TMC RO-1006 Replacement – Seals Test Scoping



Seals Tests

D7216 LDEO = 5 Elastomer Tests

- FKM1 / HNBR1 / AEM1 / ACM1 / VMQ1

D7216 HDEO = 5 *Elastomer* Tests

- FKM / NBR / VAMAC G / ACM / VMQ

All tests were run at SwRI and completed on October 14 – 27, 2016

Elastomer Compatibility Test – D7216 Annex A2 (LDEO)

150°C, 336 Hr

		DI-A / Group-II	DI-A / Group-I	DI-B / Group-II	DI-B / Group-I	Reference
Polyacrylate (ACM1-16)		Spec Limits				
Volume Change	-5, 9	2.20 (4.77)	5.56 (4.85)	1.74 (4.77)	5.27 (4.85)	See (data)
Hardness	-10, 10	2 (-2)	-2 (-3)	3 (-2)	-2 (-3)	See (data)
Tensile Strength	-40, 40	-5.7 (-8.8)	-1.9 (-1.6)	-3 (-8.8)	-5.2 (-1.6)	See (data)
Hydrogenated Nitrile (HNBR1-17)						
Volume Change	-5, 10	-0.06	1.65	-0.64	1.08	1.95
Hardness	-10, 5	0	-2	1	0	-1
Tensile Strength	-20, 15	-9.1	-4.9	-11.0	-8.9	-1.6
Silicone (VMQ1-19)						
Volume Change	-5, 40	30.08 (31.89)	32.52 (33.74)	29.42 (31.89)	31.92 (33.74)	See (data)
Hardness	-30, 10	-21 (-22)	-24 (-24)	-20 (-22)	-23 (-24)	See (data)
Tensile Strength	-50, 5	-21 (-27.6)	-35.3 (-32.8)	-21.3 (-27.6)	-24.6 (-32.8)	See (data)
Fluorocarbon (FKM1-17)						
Volume Change	-2, 3	0.44 (0.6)	0.32 (0.52)	0.41 (0.52)	0.53 (0.52)	See (data)
Hardness	-6, 6	4 (4)	5 (6)	0 (6)	0 (6)	See (data)
Tensile Strength	-65, 10	-44.6 (-52.1)	-49.3 (-53.4)	-25.6 (-53.4)	-31.9 (-53.4)	See (data)
Ethythene Acrylic (AEM1-17)						Reference
Volume Change	-5, 30	18.65	24.26	18.28	23.93	25.07
Hardness	-20, 10	-10	-14	-11	-15	-15
Tensile Strength	-30, 30	-12.4	-14.8	-6.4	-11.8	-17.7



Elastomer Compatibility Test – D7216 Annex A2 (HDEO)

150°C, 336 Hr

		DI-A / Group-II	DI-A / Group-I	DI-B / Group-II	DI-B / Group-I		Acceptable Limits
	Spec Limits	ACM-17	ACM-19	ACM-17	ACM-19	Reference	Updated on 3/1/2008
Polyacrylate (ACM)							
Volume Change	-3, 5	-0.58 (1.47)	0.96 (1.44)	-0.72 (1.47)	0.94 (1.44)	See (data)	-3.62, 5.62
Hardness	-5, 8	2 (-1)	0 (-2)	3 (-1)	0 (-2)	See (data)	-6, 9
Tensile Strength	-15, 18	10.3 (3.2)	-4.5 (1.4)	12.6 (3.2)	4.3 (1.4)	See (data)	-23.2, 26.2
Elongation	-35, 10	-9.9 (-8.1)	-10.2 (6.4)	-12.8 (-8.1)	7.3 (6.4)	See (data)	-44.1, 19.1
Nitrile (NBR-19)							
Volume Change	-3, 5	0.00	1.29	-1.02	0.56	1.79	3.62, 5.62
Hardness	-5, 7	10	10	13	11	5	-6, 8
Tensile Strength	-TMC1006, 10	-61.8	-59.2	-63.3	-61.9	-29.2	-39.8, 17.3
Elongation	-TMC1006, 10	-71	-69.1	-71.5	-70.6	-53.5	-61.6, 15.7
Silicone (VMQ1-20)							
Volume Change	-3, TMC1006	31.34	32.02	31.03	31.72	32.67	-4.50, 35.02
Hardness	-TMC1006, 5	-23	-23	-22	-22	-24	-27, 6
Tensile Strength	-45, 10	-29.9	-27.1	-26.8	-28.2	-30.0	-58.7, 15.7
Elongation	-30, 20	-24.9	-19.9	-22.6	-21.1	-24.0	-38.1, 28.1
Fluorocarbon (FKM-19)							
Volume Change	-2, 5	0.53	0.5	0.58	0.76	0.61	-2.13, 5.13
Hardness	-5, 7	7	8	0	1	9	-6, 8
Tensile Strength	-TMC1006, 10	-68.3	-69.1	-39.4	-49.2	-72.0	-78.1, 13.9
Elongation	-TMC1006, 10	-64.0	-65.5	-42.6	-47.2	-69.8	-81.5, 16.3
VAMAC-13							
Volume Change	3, TMC1006	13.96	11.19	13.59	8.56	19.75	-4.67, 22.37
Hardness	-TMC1006, 5	-6	-11	-7	-12	-12	-13, 6
Tensile Strength	-TMC1006, 10	-17.1	-14.4	-3.7	-10.6	-14.2	-25.0, 17.1
Elongation	-TMC1006, 10	-39.1	-25.4	-18.8	-14.0	-25.0	-38.0, 19.0

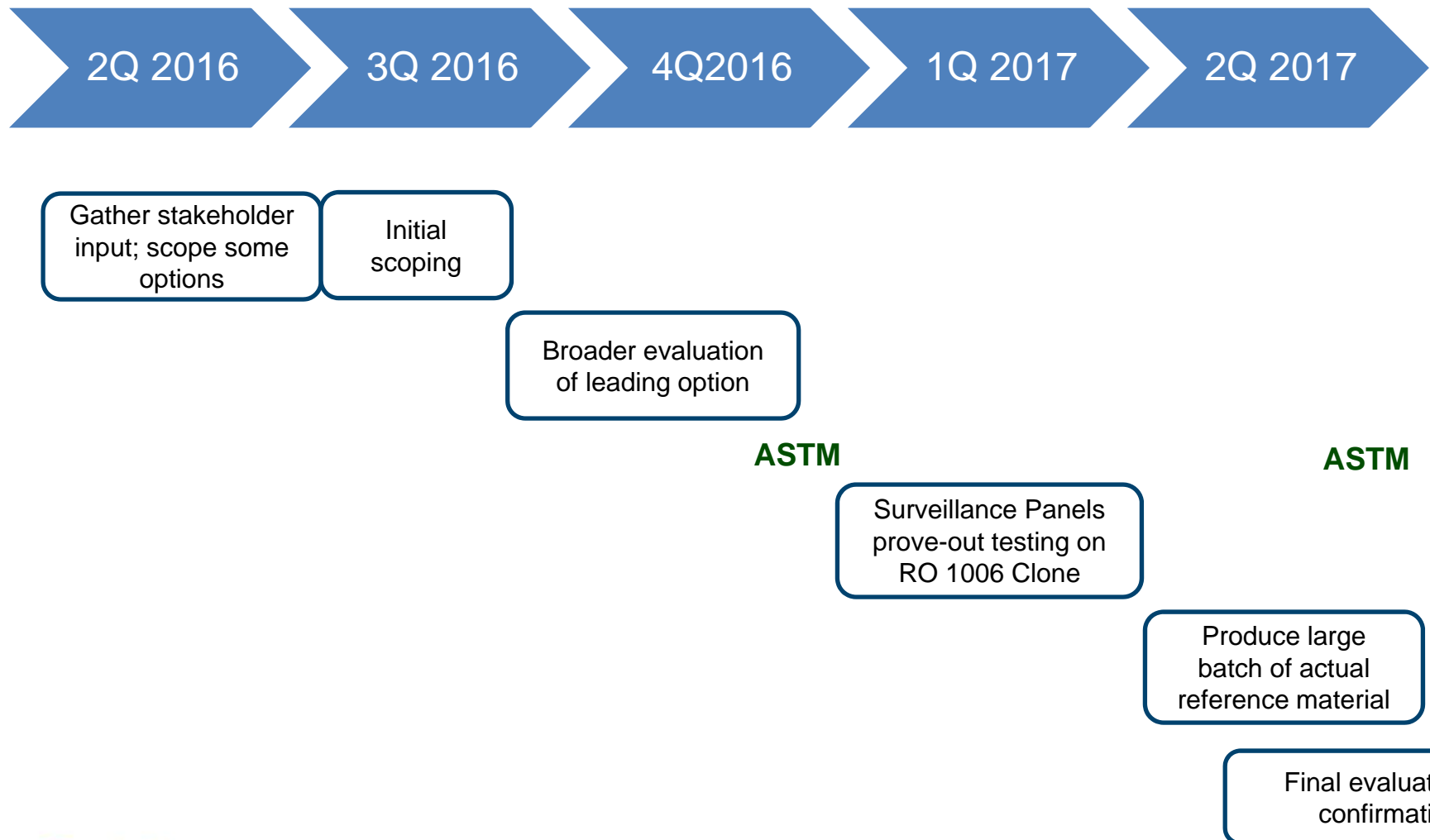


Replacement Plans

Currently Using RO 1006-2	Future Plan
HDEOEC (D4485)	RO 1006 Clone
LDEOEC (API 1509 & D4485)	RO 1006 Clone
ASTM D471 (SL 105)	RO 1006 Clone
SAE J2643 (SL 105)	RO 1006 Clone
ASTM D6891 – Seq IVA	TMC to set aside sufficient RO 1006-2 Seq IVB to use other ref. oils.
ASTM D6593 – Seq VG	RO 1006-2 Seq VH to use other ref. oils
ASTM D6709 – Seq VIII	?
ASTM D6557 – Ball Rust Test	TMC to set aside sufficient RO 1006-2



Timeline



Final Thoughts

- 📈 The selected Group I replacement basestock is expected to be available for the foreseeable future
- 📈 RO 1006 Clone will be assigned a new TMC code
- 📈 Those responsible for ASTM D471 and SAE J2643 will ultimately decide whether to use this Clone and assign a new Service Liquid #, if desired
- 📈 EOEC SP continues efforts to improve r&R
- 📈 Task Force will continue efforts to set fixed limits in HDEOEC





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