Rubber Consultants
Brickendonbury, Hertford, SG13 8NL, UK
T: +44 (0)1992 554657
E: info@rubberconsultants.com
www.rubberconsultants.com
@rubberconsultan

CONFIDENTIAL TECHNICAL REPORT

RC30171A

Technical Report on the testing of one Vamac (AEM) material to EN549 (Seal properties)

For the attention of:
Andrew Thomas of PRIMASIL SILICONES LTD

Checked by:

Issued by:

S. Moazami

Sarah Moazami

Date of issue: 5th January 2022

Position:
Physical Testing technician

Summary
One sample of a Vamac (AEM) material was submitted for testing by Primasil Silicones Ltd., the testing was to be conducted to meet the requirements of a Class H2/C1 Seal Compound of EN549:2019.
Sample PRI 07V/60 (EA2753/6) failed to meet the requirements for an H2/C1 class as specified in EN549:2019 with regard to Resistance to condensate(change in mass after immersion).

Materials and Methods

One rubber compound labelled PRI 07V/60 (EA2753/6), and consisting of two (250 x 300 x 2) mm sheets with 2 blocks and 31 compression set buttons, was received 1st December 2021 and given the goods received number GR21/423 for internal tracking purposes. The following tests were conducted in accordance with EN549:2019 to meet the requirements of an H2/C1 class material for seals.

Tensile testing to BS ISO 37

Two sets of six Type 2 tensile dumb-bells, of nominal thickness 1.80 to 2.2mm, were cut from the sheet, using an appropriate die and a manual cutting press, in the direction of the grain. The thickness of each test piece was measured using a Mitutoyo digital thickness gauge. The tensile dumb-bells were pulled to failure at a rate of 500mm/min using an Instron 5567 materials testing system equipped with an advanced video-extensometer (AVE) and operating under Instron's Bluehill 2 test control software. The modulus values (at every 100% elongation), the tensile strength and the elongation at break were recorded.

One set of six test pieces was tested unaged. The second set was tested following ageing in air at an elevated temperature of 125° C for a period of 168 hours. The results are recorded in table 1.

Hardness Testing to BS ISO 48-2 Method M

Three sets of three (20 x 50)mm test pieces were cut from the 2mm thick sheet. The test pieces were cut using the appropriate die cutter and a manual cutting press. The hardness of each test piece was measured in accordance with BS ISO 48 -2 Method M (Microhardness) using a Wallace Cogenix H12 Microhardness test system. The initial hardness value of each test piece was recorded at five points.
One set of three test pieces was aged in an oven at a temperature of 125°C for 168 hours. The aged test pieces were allowed to equilibrate, after removal from the oven, under standard laboratory conditions, a temperature of 23 +/-2 ^{0}C and relative humidity 50 +/10% for a minimum of 16 hours prior to testing. The second set was tested following immersion in IRM 902 Oil for 168 hours at 100°C In accordance with BS ISO 1817. The results are recorded in Table 1.

Compression set testing to BS ISO 815-1 Method A

Two sets of three type B compression set buttons were tested in accordance with the standard. The test conditions were 25% strain with a test duration of 72hours at a temperature of 0° C, and 25% strain with a test duration of 24 hours at a temperature of 125°C. The test pieces were measured and then compressed by 25% in lubricated jigs .One jig was placed in a freezer at 0°C, the second jig was placed in an oven at 125°C. After 24 hours the jig was opened and the test pieces allowed to recover for 30 minutes under standard laboratory conditions before being re-measured. The jig in the freezer was opened after 72 hours and the test pieces allowed to recover for 30 minutes at 0°C before being measured. The results are recorded in Table 1.

Resistance to Ozone cracking testing to BS ISO 1431-1: Procedure A

Three test strips, 10mm x 120mm were cut from the sheet, parallel to the grain, using a strip cutter and manual cutting press. The strips were mounted in jigs, clamped in place, and extended to 20% strain. The cut edges were sealed (coated) with a film of molten paraffin wax. The test pieces were conditioned in darkness, in the pre-strained state, for a period of 72 hours at standard laboratory temperature of 23 +/- 2°C and 50 +/-5 % relative humidity.

The test strips were examined under X7 magnification, using a hand lens, prior to transfer to the ozone test cabinet. The jigs were suspended within the test chamber, and exposed to an ozone concentration of 50 +/- 5pphm, at a temperature of 30 +/-2 °C, for a period of 24 hours.

The Satra Hampden HTE-P3C6R test chamber generates ozone on passing air over an ultra violet (UV) light source. The ozone concentration within the chamber was monitored, and controlled using an integral UV analyser detector and control system. The flow of air through the test chamber was equivalent to an air-ozone replacement rate of 1.2 changes per minute; equivalent to an airflow rate of $0.003 m^3 s^{-1}$ and a velocity of $0.012 ms^{-1}$. The test pieces were removed from the test chamber on completion of the study and examined under X7 magnification using a hand lens. The results are recorded in Table 1.

Determination of the effect of liquids TO BS ISO 1817

Three sets of 3 (20 x50)mm test pieces were cut from the sheet using an appropriate die and a manual cutting press. The test pieces were weighed in air using an Ohaus balance, accurate to 0.001g. One set of test pieces was immersed in n-pentane(in accordance with BS ISO 1817) for 72 hours at 23°C.The test pieces were then removed, cleaned, reweighed, and then placed in an oven for 168 hours at 40°C . After 168 hours the test pieces were removed from the oven, allowed to condition for 16 hours under standard laboratory conditions, and reweighed. The changes in mass were calculated and recorded. The second set was immersed in IRM 902 oil (in accordance with BS ISO 1817) for 168 hours at 100°C. On completion of 168 hours the test pieces were placed in the appropriate fresh liquid at 23°C and allowed to cool for 30 minutes. The test pieces were cleaned, re-weighed, and the change in mass calculated. The third set of test pieces were place in Liquid B for 72 hours at 23°C. At the end of 72 hours the test pieces were cleaned and reweighed, then placed in an oven for 96 hours at 70°C. After the 96 hours the test piece were removed from the oven, allowed to condition under standard laboratory conditions for 16 hours and re-weighed. The changes in mass were

calculated. The results are recorded in Table 1. The resistance to condensate test was repeated to confirm the initial results. The repeated result is reported in brackets in table 1.

Table 1.

PRI 07V/60 (EA2753/6) Tested to EN549 :2019 H2/C1	Method		Test Result	Specification	Pass/Fail
Tensiles unaged	ISO 37	Tensile Strength (MPa)	17.51	≥ 7	Pass
		Elongation at break (%)	299	≥ 125	Pass
Tensiles aged 168hr @ 125°C	ISO 37	Tensile Strength (MPa)	17.48	Max. Change -40%	Pass
		Elongation at break (%)	277	Max. Change -40%	Pass
Microhardness unaged	ISO 48	IRHD	59	55-65	Pass
Microhardness aged 168hr @ 125°C	ISO 48	IRHD	59	Max. Change +/- 8	Pass
Comp set 24hr @ 125°C	ISO 815	(%)	8	≤40	Pass
Comp set 72hr @ 0°C	ISO 815	(%)	14	≤40	Pass
Change in mass on immersion in pentane 72hr at 23°C	ISO 1817	(%)	7.35	+10 / - 5%	Pass
Change in mass on drying for 168hr @ 40°C		(%)	-6.43	Max. Change + 5 / - 8%	Pass
Change in mass on immersion in Liquid B 72hr at 23°C	ISO 1817	(%)	49.25(48.0)	+20%	Fail
Change in mass on drying for 96hr @ 70°C		(%)	-7.96	-12%	Pass
Change in mass 168hr @ 100°Cin IRM 902 OIL		(%)	9.0	Max. Change +15% / -10%	Pass
Microhardness unaged	ISO 48	IRHD	59	55-65	
Microhardness aged in IRM 902 Oil, 168hr @ 100°C	ISO 48	IRHD	53	Max. Change +/- 10	Pass
Resistance to ozone 24hr, 20% str, 30°C, 50pphm ozone	ISO 1431-1 Procedure A		No cracks	No cracks	Pass

Sample PRI 07V/60 (EA2753/6) failed to meet the requirements for an H2/C1 class as specified in EN549:2019 with regard to Resistance to condensate(change in mass after immersion).
Copies of the laboratory reports labelled 26248 26248A , and 26248B and 26248repeat are appended.

TO: RC30171

Checked
Date 7/12/21

TENSILE PROPERTIES (MPa)

Reference:30171.05.01
Tested by / Prepared by: SM/SM
Instron 5567
Cutter Type: Type 2

Test Lab Reference : 26248
Date of test : 3.12.21
Aged : Unaged/23°C

Lab. Temp 23+/-2°C
Lab.Relative Humidity 50+/-10%

Test pieces cut with grain

Tested to EN 549 :2019

Sample ID	100%	200%	300%	400%	500%	T.S.	E.B.	Th. (mm)	CODE
01	3.52	11.62	17.58	-------	-------	17.92	311	2.38	
PRI 07V/60	3.66	11.86	-------	-------	-------	17.62	299	2.39	
(EA2753/6)	3.77	11.81	17.53	-------	-------	17.97	313	2.40	
	4.83	13.64	-------	-------	-------	17.36	263	2.42	
	4.03	12.18	-------	-------	-------	17.40	293	2.44	
	3.84	11.64	-------	-------	-------	17.24	299	2.47	

N.B.
The compound is of a non standard thickness

Codes

Underlined value is the median

1 = Grip Break
2 = Sample slipped
3 = Extensometer stopped following marks (modulus data valid to E.B. indicated)
4 = Break not detected
5 = Neck break
6 = other

TO: RC 30171

Checked: [signature]
Date: 15/12/21

TENSILE PROPERTIES (MPa)

Reference: 30171.05.01
Tested by / Prepared by: CZ/SM, CZ
Instron 5567
Cutter Type: Type 2

Test Lab Reference : 26248A
Date of test : 14/12/2021
Aged : 168 Hours/125°C

Lab. Temp 23+/-2°C
Lab.Relative Humidity 50+/-10%

Test pieces cut with grain

Tested to EN549:2019

Sample ID	100%	200%	300%	400%	500%	T.S.	E.B.	Th. (mm)	CODE
01	4.96	13.50	-------	-------	-------	17.40	277	2.35	
PRI 07V/60	4.94	13.61	-------	-------	-------	17.37	270	2.35	
(EA2753/6)	4.96	13.56	-------	-------	-------	17.40	274	2.36	
	5.16	13.84	-------	-------	-------	17.66	277	2.34	
	4.75	13.51	-------	-------	-------	17.67	278	2.37	
	4.78	13.26	-------	-------	-------	17.56	284	2.35	

NB. Mix is of a non-standard thickness.

Codes

Underlined value is the median

1 = Grip Break
2 = Sample slipped
3 = Extensometer stopped following marks (modulus data valid to E.B. indicated)
4 = Break not detected
5 = Neck break
6 = other

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Checked D. Hagan
Date 15/12/21

TENSILE PROPERTIES (MPa)

Reference: 30171.05.01

Test Lab Reference : 26248A
Tested to EN549:2019

Sample		UNAGED Median	AGED Median	% Change
1	100%	3.81	4.95	29.92
PRI07V/60	200%	11.84	13.54	14.36
(EA2753/6)	300%	17.56		-100.00
	400%			
	500%			
	T.S.	17.51	17.48	-0.17
	E.B(%)	299	277	-7

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Checked---
Date---7/12/21

MICROHARDNESS

Reference : 30171.05.01
Tested by / Prepared by : SM/SM
Test Temp (°C) : 23
Type of Surface : Moulded
Sample Type : 50 x 20 x2mm sheet

Test Lab Reference : **26248**
Date of test : 2.12.21
Aged : Unaged/23°C
Tested to EN549 Class H2/C1

Sample Identification	No.	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	MEDIAN
PRI 07V/60	1	60	60	60	59	59	60
(EA2753/6)	2	59	58	58	57	58	58
	3	60	60	60	59	60	60
	4	58	59	59	58	58	58
	5	58	59	59	59	59	59
	6	59	59	59	59	59	59

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Checked
Date 15/12/2021

MICROHARDNESS

Reference : 30171.05.01
Tested by / Prepared by : CZ/SM
Test Temp (°C) : 23
Type of Surface : Moulded
Sample Type : 50 x 20 x2mm sheet

Test Lab Reference : **26248A**
Date of test : 14/12/2021
Aged : 168 Hours/125°C
Tested to EN549 Class H2/C1

Sample Identification	No.	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	MEDIAN
PRI 07V/60	1	59	59	59	59	59	59
(EA2753/6)	2	59	59	58	58	58	58
	3	59	59	60	59	60	59

TO: RC 30171

Checked S. Hogan
Date 8/12/21

COMPRESSION SET

Reference : 30171.05.01
Tested by /prepared by : CZ/CZ
Lab Temp(°C): 23

Test Lab Reference : **26248**
Date of test : 06/12/2021
Aged : Unaged/23°C
Tested to : EN549:2019

Compression (%) = 25
Test Temp (°C) = 125
Test duration = 24 Hours
Recovery Time/ Temp. = 30 Minutes/23°C

Silicone fluid lubricant used.
Micrometer foot diameter = 4 mm.
The test pieces were tested as a set.

The sample is a moulded cylindrical disc of diameter 13mm, thickness 6.3mm (Type B in standard) and it is not laminated. If the test-piece thickness is non-standard the achieved compression will be quoted.

	Compression Set %			
Sample Identification	Test Piece 1	Test Piece 2	Test Piece 3	MEDIAN %
Mix 01 PRI07V/60 (EA2753/6)	8	8	7	8

TO: RC 30171

Checked D. Morgan
Date 9/12/21

COMPRESSION SET

Reference : 30171.05.01
Tested by /prepared by : CZ/CZ
Lab Temp(°C): 23

Test Lab Reference : **26248A**
Date of test : 06/12/2021
Aged : Unaged/23°C
Tested to : EN549 :2019

Compression (%) = 25
Test Temp (°C) = 0
Test duration = 72 Hours
Recovery Time/ Temp. = 30 Minutes @ 0°C

Silicone fluid lubricant used.
Micrometer foot diameter = 4 mm.
The test pieces were tested as a set.

The sample is a moulded cylindrical disc of diameter 13mm, thickness 6.3mm (Type B in standard) and it is not laminated. If the test-piece thickness is non-standard the achieved compression will be quoted.

	Compression Set %			
Sample Identification	Test Piece 1	Test Piece 2	Test Piece 3	MEDIAN %
01 PRI07V/60 (EA2753/6)	12	14	15	14

TO: RC 30171

Checked: D. Morgan
Date: 15/12/21

% WEIGHT CHANGE

Reference : 30171.05.01
Tested by : CZ
Sample Type: (50 x 20 mm) pieces.

Test Lab Reference : **26248**
Date of test : 03/12/2021
AGED: **Swollen for 72 hours @ 23°C in Pentane,weighed Dried for 168 Hours @ 40°C, conditioned for 16 hours, then re-weighed**

Sample Identification	No	WEIGHT(mg) before swelling	WEIGHT(mg) Immediately After swelling	%WEIGHT CHANGE	WEIGHT (mg) After drying for 168 hours/40°C	% WEIGHT CHANGE
Mix 01	1	2962	3181	7.39	2773	-6.38
PRI07V/60 (EA2753/6)	2	2763	2963	7.24	2583	-6.51
	3	2736	2939	7.42	2561	-6.40

TO: RC 30171

Checked S. Magni
Date 15/12/21

% WEIGHT CHANGE

Reference : 30171.05.01
Tested by : CZ
Sample Type: (50 x 20 mm) pieces.

Test Lab Reference : **26248A**
Date of test : 06/12/2021
AGED: **Swollen for 72 hours @ 23°C in Liquid B,weighed Dried for 96 Hours @ 70°C, conditioned for 16 hours, then re-weighed**

Sample Identification	No	WEIGHT(mg) before swelling	WEIGHT(mg) Immediately After swelling	%WEIGHT CHANGE	WEIGHT (mg) After drying for 168 hours/40°C	% WEIGHT CHANGE
Mix 01	7	2851	4250	49.07	2623	-8.00
PRI07V/60 (EA2753/6)	8	2856	4264	49.30	2630	-7.91
	9	2762	4126	49.38	2542	-7.97

TO: RC 30171

Checked J. Morgan
Date 5/1/22

% WEIGHT CHANGE

Reference : 30171.05.01
Tested by : CZ
Sample Type: (50 x 20 mm) pieces.

Test Lab Reference : **26248Repeat**
Date of test : 17/12/2021
AGED: **Swollen for 72 hours @ 23°C in Liquid B,weighed Dried for 96 Hours @ 70°C, conditioned for 16 hours, then re-weighed**

Sample Identification	No	WEIGHT(mg) before swelling	WEIGHT(mg) Immediately After swelling	%WEIGHT CHANGE	WEIGHT (mg) After drying for 168 hours/40°C	% WEIGHT CHANGE
Mix 01	7	2802	4159	48.43		
PRI07V/60 (EA2753/6)	8	2904	4299	48.04		
	9	2796	4150	48.43		

TO:RC30171

Checked---
Date--- 15/12/21

% WEIGHT CHANGE

Reference :30171.05.01
Tested by/ Prepared by :SM/CZ
Sample Type: (50 x 20 x 2)mm Sheet

Test Lab Reference : **26248B**
Date of Test: 8.12.21
Aged: 168hrs/100°C/902 Oil
Tested to: EN 549:2019 Class H2/C1

Sample Identification	No	WEIGHT(mg) before ageing	WEIGHT(mg) After ageing	%WEIGHT CHANGE	Mean % weight Change
01	4	2766	3015	9.0	
PRI 07V/60	5	2755	3004	9.0	9
(EA2753/6)	6	2869	3131	9.1	

TO:RC30171

Checked---
Date---15/12/21

MICROHARDNESS

Reference : 30171.05.01
Tested by / Prepared by : SM/SM
Test Temp (°C) : 23
Type of Surface : Moulded
Sample Type : (50 x 20 x2)mm sheet

Test Lab Reference : **26248B**
Date of test : 15.12.21
Aged : 168 hours/100°C/902 Oil
Tested to EN549 Class H2/C1

Sample Identification	No.	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	MEDIAN
01	4	52	52	52	52	52	52
PRI 07V/60	5	52	53	53	52	53	53
(EA2753/6)	6	52	53	53	53	53	53

TO: RC 30171

Checked: D. Mac
Date: 7/12/21

OZONE TEST

Reference : 30171.05.01
Tested by / Prepared by : CZ/CZ
Test Temperature (°C) : 40
Conditioned for: 48 to 96 hours/23°C
Test Duration (hours) : 24
Strain (%) : 20
Ozone Concentration (pphm) : **50**

Test Piece Type : 10mm wide strip

Test Lab Reference : **26248**
Date of test : 06/12/2021
Aged : Unaged/23°C

Tested to EN549:2019

Sample Identification	TIME	Test Piece No.	OBSERVATIONS
PRI 07V/60 (EA 2753/6)	24 Hours	1	No cracks, no bloom.
		2	No cracks, no bloom.
		3	No cracks, no bloom.