BAM

Bundesanstalt für Materialforschung und -prüfung

Report

on Testing a Nonmetallic Material for Reactivity with Oxygen

Reference Number	2-1690/2014 II E
Copy	1st Copy of 2 Copies
Customer	SGL CARBON GmbH Werner-von-Siemens-Straße 18 86405 Meitingen Germany
Order Date	July 15, 2014
Reference	Order no.: 114-10-45767390
Receipt of Order	July 15, 2014
Test Samples	Sigraflex® APX2 Hochdruck, undisclosed batch, for use as a gasket material in flanged connections in piping, valves and fittings or other components for gaseous oxygen service at temperatures up to 300 °C and pressures up to 160 bar as well as for liquid oxygen service; BAM-Order No.: 2.1/52 204
Receipt of Samples	July 22, 2014
Test Date	August 21, 2014 to March 6, 2015
Test Location	BAM - Working Group "Safe Handling of Oxygen"; building no. 41, room no. 073 and no. 120
Test Procedure or Requirement According to	DIN EN 1797:2002-02 „Cryogenic Vessels - Gas/Material Compatibility" ISO 21010:2004-14 „Cryogenic Vessels - Gas/Material Compatibility" Annex of pamphlet M 034-1 (BGI 617-1) "List of nonmetallic materials compatible with oxygen by BAM Federal Institute for Material Research and Testing.", by Berufsgenossenschaft Rohstoffe und chemische Industrie, Edition: March 2014; TRGS 407 Technical Rules for Hazardous Substances "Tätigkeiten mit Gasen - Gefährdungsbeurteilung" chapter 3 "Informationsermittlung und Gefährdungsbeurteilung" and chapter 4 "Schutzmaßnahmen bei Tätigkeiten mit Gasen" Edition: June 2013

All pressures of this report are excess pressures.
This test report consists of page 1 to 5 and annex 1 to 4.

1 Documents and Test Samples

The following documents and samples were submitted to BAM:

1 Test Application
1 Material Data Sheet,
(2 pages, date of issue: June 2014)
1 Safety Data Sheet,
(5 pages, version: 1.01, date of issue: July 25, 2014)
15 Disks of Sigraflex® APX2 Hochdruck, undisclosed batch,
one side labeled with Sigraflex® APX2 Hochdruck
Outer-Ø: 150 mm; Thickness: 2 mm;
Color: Light grey

2 Test Methods

To evaluate the compatibility of Sigraflex® APX2 Hochdruck, undisclosed batch, for use as a gasket material in in flanged connections in piping, valves and fittings or other components for gaseous oxygen service at temperatures up to 300 °C and pressures up to 160 bar, a determination of the autogenous ignition temperature (AIT) and an investigation of the aging resistance in high pressure oxygen as well as flange testing were carried out.

The compatibility of the nonmetallic material with liquid oxygen was tested by its reactivity with liquid oxygen on mechanical impact.

3 Results

3.1 Autogenous Ignition Temperature (AIT)

Based on costumer's specification of the maximum operating pressure, the autogenous ignition temperature test was performed at a final oxygen pressure of approximately 160 bar. The test method is described in annex 1.

Results:

Test No.	Initial Oxygen Pressure p_I [bar]	Final Oxygen Pressure p_F [bar]	AIT [°C]
1	62	163	> 500
2	62	165	> 500
3	62	165	> 500
4	62	163	> 500
5	62	166	> 500

Up to temperatures of 500 °C, no ignition of the sample could be detected in five tests with initial oxygen pressures of p_I = 62 bar. The final oxygen pressure p_F was approximately 164 bar.

3.2 Artificial Aging

In general, the aging test is carried out at the maximum operating pressure and at an elevated temperature, which is 25 °C above the maximum operating temperature. In this case, the aging test was carried out at 325 °C and at 160 bar. The test method is described in annex 2.

Results:

Time [h]	Temperature [°C]	Oxygen Pressure [bar]	Mass Change [%]
100	325	160	- 0.6

After aging of the test sample at 325 °C and at 160 bar oxygen pressure, the test sample was apparently unchanged. The sample lost 0.6 % in mass.

3.2.1 AIT after Artificial Aging

The test method is described in annex 1.

Results:

Test No.	Initial Oxygen Pressure p_I [bar]	Final Oxygen Pressure p_F [bar]	AIT [°C]
1	62	164	> 500
2	62	164	> 500
3	62	165	> 500
4	62	165	> 500
5	62	163	> 500

Up to temperatures of 500 °C, no ignition of the aged sample could be detected in five tests with initial oxygen pressures of p_I = 62 bar. The final oxygen pressure p_F was approximately 164 bar. This shows, that, as the non-aged sample, also the aged sample did not ignite at temperatures up to 500 °C.

3.3 Flange Test

The test method is described in annex 3.

Results:

Test no.	Oxygen Pressure [bar]	Temperature [°C]	Notes
1	160	300	Only those parts of the gasket burn that project into the pipe
2	160	300	same behavior as in test no. 1
3	160	300	same behavior as in test no. 1
4	160	300	same behavior as in test no. 1
5	160	300	same behavior as in test no. 1

In five tests at 160 bar oxygen pressure and 300 °C, only those parts of the gasket burn that project into the pipe; the fire is neither transmitted to the steel nor does the gasket burn between the flanges. The flange remains gas-tight.

3.4 Reactivity with Liquid Oxygen on Mechanical Impact

In general, a nonmetallic material is not compatible with liquid oxygen, of reactions occur at a drop height of 0.17 m (impact energy 125 Nm) or less. The test method is described in annex 4.

Results:

Test No.	Drop Height [m]	Impact Energy [Nm]	Reaction
1	0.83	625	no reaction
2	1.00	750	no reaction
3	1.00	750	no reaction
4	1.00	750	no reaction
5	1.00	750	no reaction
6	1.00	750	no reaction
7	1.00	750	no reaction
8	1.00	750	no reaction
9	1.00	750	no reaction
10	1.00	750	no reaction
11	1.00	750	no reaction

At a drop height of 1.00 m (impact energy 750 Nm), in ten separate tests, no reaction of the nonmetallic material Sigraflex® APX2 Hochdruck, undisclosed batch, with liquid oxygen could be detected.

4 Summary and Evaluation

Up to temperatures of 500 °C, no ignition of the gasket material Sigraflex® APX2 Hochdruck, undisclosed batch, could be detected in five tests with final oxygen pressures of p_F = 164 bar.

At a temperature of 325 °C and an oxygen pressure of 160 bar, the material proved to be aging resistant. The sample lost 0.6 % in mass.

Up to temperatures of 500 °C, no ignition of the aged gasket material could be detected in five tests with final oxygen pressures of approximately p_F = 164 bar. This shows, that, as the non-aged sample, also the aged sample did not ignite at temperatures up to 500 °C.

Generally, in evaluating nonmetallic materials for oxygen service, a safety margin of 100 °C between AIT and maximum operating temperature is being considered for safety reasons. As the maximum operating temperature is 300 °C, the gasket material Sigraflex® APX2 Hochdruck, undisclosed batch, fulfills this criterion.

On basis of those test results and the results of the flange testing and the pre-condition, that any oxygen pressure impacts during operation con be safely excluded, there are no objections with regard to technical safety to use the tested batch of the gasket material Sigraflex® APX2 Hochdruck with a maximum thickness of 2 mm in flange connections made of copper, copper alloys or steel at following conditions:

Maximum Temperature [°C]	Maximum Oxygen Pressure [bar]
300	160

This applies to flat faced flanges, male/female flanges, and flanges with tongue and groove.

According to the BAM-Standard "Testing for Reactivity with Liquid Oxygen on Mechanical Impact", described in annex 4, there are no objections with regard to technical safety to use the gasket material Sigraflex® APX2 Hochdruck, undisclosed batch in piping, valves and fittings or other components for liquid oxygen service. In this case, a limitation to a particular pressure range is not necessary as compression of liquid oxygen causes no significant change in concentration and therefore has no considerable influence on the reactivity of the nonmetallic material.

5 Comments

The test results refer exclusively to the tested batch of the nonmetallic gasket material Sigraflex® APX2 Hochdruck.

Products on the market that contain a reference to BAM testing shall be marked accordingly. It shall be evident that only a sample of a batch has been tested and evaluated for oxygen compatibility. The reference shall not produce a presumption of conformity that monitoring of the production on a regular basis is being performed by BAM.

It shall be clear that the product may only be used for gaseous oxygen service and liquid oxygen service. The maximum safe oxygen pressure of the product and its maximum operating temperature as well as other restrictions in use shall be given.

BAM Federal Institute for Materials Research and Testing
12200 Berlin, March 17, 2015

Division 2.1
"Gases, Gas Plants"

On behalf of

Dr. Thomas Kasch

Copies: 1. Copy: SGL CARBON GmbH
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