

Report

on Testing non-metallic Material for Reactivity with Oxygen

Reference Number	2-2126/2013 E
Copy	1. Copy of 2 Copies
Customer	W. L. GORE & ASSOCIATES GmbH Wernher-von-Braun-Straße 18 85640 Putzbrunn
Order Date	July 25, 2013
Reference	Order No.: 20525832
Receipt of Order	July 26, 2013
Test Samples	Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country GERMANY), for use in flanged connections in piping, valves and fittings or other components for gaseous oxygen service at temperatures up to 60 °C. BAM-Order No.: 2.1/51 680
Receipt of Samples	July 26, 2013
Test Date	September 13, 2013 to January 6, 2014
Test Location	BAM - Working Group "Safe Handling of Oxygen"; building no. 41, room no. 073
Test Procedure or Requirement According to	DIN EN 1797: 2002-02 „Cryogenic Vessels - Gas/Material Compatibility“ ISO 21010: 2004-07 „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 German Social Accident Insurance Institution for the raw materials and chemical industry, Edition: March 2013; Rule BGR 500 "Betreiben von Arbeitsmitteln" part 2, chapter 2.32 "Betreiben von Sauerstoffanlagen", paragraph 3.17 "Lubricants and sealing materials", Edition: April 2008.

All pressures of this report are excess pressures.
This test report consists of page 1 to 5 and annex 1 to 3.

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In case a German version of the test report is available, exclusively the German version is binding.

TEST REPORT



1 Documents and Test Samples

The following documents and samples were submitted to BAM:

1 Test Application

„Testing the reactivity of Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country GERMANY), with gaseous oxygen at 110 °C and 40 bar and an extra determination of the autogenous ignition temperature at 6 bar oxygen pressure.“

10 m Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country GERMANY)

Width 15 mm; Thickness 5,5 mm

Colour: White

2 Test Methods

To evaluate the compatibility of the Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country GERMANY), for gaseous oxygen service at temperatures up to 110 °C and a maximum oxygen pressure of 40 bar the determination of the autogenous ignition temperature (AIT), an investigation of the aging resistance in high pressure oxygen, and a flange test were carried out.

Based on the test application, an extra determination of the autogenous ignition temperature at 6 bar oxygen pressure was carried out.

3 Results

3.1 Autogenous Ignition Temperature (AIT)

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	28	42	146
2	28	42	144
3	28	42	134
4	28	43	140
5	28	43	147

In five tests with an initial oxygen pressure of $p_i = 28$ bar, an AIT of 142 °C was determined with a standard deviation of ± 5 °C. The oxygen pressure p_F at ignition is approximately 42 bar.

3.1.1 Autogenous Ignition Temperature (AIT) at 6 bar oxygen pressure

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	4	8	164
2	4	8	182
3	4	8	160
4	4	8	168
5	4	8	178

In five tests with an initial oxygen pressure of $p_i = 4$ bar, an AIT of 170 °C was determined with a standard deviation of ± 9 °C. The oxygen pressure p_F at ignition is 8 bar.

3.2 Artificial Aging

The test method is described in annex 2.

Results:

Time [h]	Temperature [°C]	Oxygen Pressure [bar]	Mass Change [%]
100	112	40	- 0,3

After aging of the test sample of Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country Germany), at 109 °C and an oxygen pressure of 40 bar the adhesive surface was burnt. The sample lost 0.3 % in mass.

3.2.1 AIT after Artificial Aging

The test method is described in annex 1.

Results:

Number of Tests	Initial Oxygen Pressure p_i [bar]	Final Oxygen Pressure p_F [bar]	AIT [°C]
1	28	52	436
2	28	54	453
3	28	54	455
4	28	55	458
5	28	54	452

In five tests with an initial oxygen pressure of $p_i = 28$ bar, an AIT of 451 °C was determined with a standard deviation of ± 9 °C. The final oxygen pressure p_F at ignition is approximately 54 bar. This shown, that the AIT of the aged sample is significantly greater than the AIT of the non-aged sample.

3.3 Flange Test

The test method is described in annex 3.

Results:

Number of Tests	Temperature [°C]	Oxygen Pressure [bar]	Notes
1	110	40	Only those parts of the gasket burn that project into the pipe. The flange connection remains gas-tight.
2	110	40	Same behavior as in test no. 1
3	110	40	Same behavior as in test no. 1
4	110	40	Same behavior as in test no. 1
5	110	40	Same behavior as in test no. 1

In five tests at 40 bar oxygen pressure and 60 °C, only those parts of the Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country Germany), 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.

4 Summary and Evaluation

The tests have shown that the autogenous ignition temperature (AIT) of the gasket material Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country Germany), is 170 °C at 8 bar oxygen pressure. The standard deviation of the AIT is ± 9 °C.

The tests have shown that the autogenous ignition temperature (AIT) of the gasket material Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country Germany), is 142 °C at 42 bar oxygen pressure. The standard deviation of the AIT is ± 5 °C.

At a temperature of 112 °C and an oxygen pressure of 40 bar, the material proved to be insufficient aging resistant. The adhesive surface was burnt and the sample lost 0,3 % in mass.

The AIT of the aged gasket material Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country Germany), is 142 °C at 42 bar oxygen pressure. The standard deviation of the AIT is ± 5 °C.

This shown, that the AIT of the aged sample is significantly greater than the AIT of the non-aged sample. In this case the ascertained difference of the AIT has not influence of the application in oxygen.

On basis of the test results and a safety margin of 50 °C between AIT and maximum operating temperature, which has to be considered for safety reasons, there are no objections with regard to technical safety to use the material Gore Series 500 Gasket Tape with an adhesive surface strip on one side, Lot-Nr. 11611888 (Producing Country Germany), in flange connections made of copper, copper alloys or steel at following conditions:

Maximum Temperature	Maximum Oxygen Pressure
up to 60 °C	up to 40 bar

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

This evaluation does not cover the use of the material for liquid oxygen service. For this application, a particular test for reactivity with liquid oxygen needs to be carried out.

5 Comments

This evaluation based exclusively on the test results of Lot-Nr. 11611888 (Producing Country Germany) of Gore Series 500 Gasket Tape with an adhesive surface strip on one side.

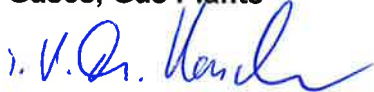
Products on the market that contain a reference to BAM testing shall be marked accordingly. It shall be evident that only a sample of a batch has been tested and evaluated for oxygen compatibility. The reference shall not produce a presumption of conformity that monitoring of the production on a regular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

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

**BAM Federal Institute for Materials Research and Testing
12200 Berlin, January 17, 2014**

Division 2.1

"Gases, Gas Plants"



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Annex 1

Determination of the Autogenous Ignition Temperature in High Pressure Oxygen

A mass of approximately 0.1 g to 0.5 g of the pasty or of the divided solid sample is placed into an autoclave (34 cm³ in volume) with a chrome/nickel lining. Liquid samples are applied onto ceramic fiber.

The autoclave is pressurized to the desired pressure p_a at the beginning of the test. A low-frequency heater inductively heats the autoclave in an almost linear way at a rate of 110 K/min. The temperature is monitored by means of a thermocouple at the position of the sample.

The pressure in the autoclave is measured by means of a pressure transducer. Pressure and temperature are recorded. During the test, as the temperature increases, the oxygen pressure increases within the autoclave. The ignition of the sample can be recognized by a sudden rise in temperature and pressure. The oxygen pressure on ignition p_e is calculated.

It is important to know the oxygen pressure p_e , as the autogenous ignition temperature of a material is a function of pressure. It may decrease as the oxygen pressure increases.



- Working Group "Safe Handling of Oxygen" -

Annex 2

Testing for Aging Resistance in High Pressure Oxygen

A sample with known mass is exposed to high-pressure oxygen at elevated temperature in an autoclave for 100 hours. The temperature, at which the sample is aged, is at least 100 °C lower than the autogenous ignition temperature of the sample.

This test shows whether the sample gradually reacts with oxygen or whether it undergoes other visible changes. If there is no change in appearance, in mass, and in the autogenous ignition temperature of the material, it is considered aging resistant.



Annex 3

Testing of Gaskets for Flanges in Oxygen Steel Pipings

The test apparatus mainly consists of two DN 65 PN 160 steel pipes, each approximately 2 m in length, with corresponding standard flanges welded to each pipe.

Both pipes are sealed using the gasket to be tested. In case of a gasket disk its inner diameter is chosen in such a way that it projects into the pipe. If a gasket tape is under test, both ends of the tape are allowed to project into the pipe. The test apparatus is then pressurized with oxygen up to the desired test pressure. The flange is heated by heating sleeves to the test temperature, at least 50 K lower than the ignition temperature of the gasket. An electrical filament ignites that part of the gasket projecting into the pipe. If the gasket is electrically conductive, such as spiral seals or graphite foils, a nonconductive primer capsule of organic material (PTFE, rubber) is used which acts on the seal.

The gasket's behavior after ignition is important for its evaluation. If the seal burns with such a hot flame that the fire is transmitted to the steel of the flange (in most case the test apparatus is destroyed), the seal is considered unsuitable from the beginning. If only those parts of the seal burn that project into the pipe and the fire is not transmitted to the flanges and if the seal does not burn between the flanges there are no objections with regard to technical safety to use the seal under the conditions tested. Such a positive result is to confirm in four additional tests. If, however, the flanged connection becomes un-tight during a test, e. g., because of softening or burning of the seal, the test has to be continued at a lower temperature and oxygen pressure until a positive test result is reached in five tests, as mentioned above.

