Bundesanstalt für
Materialforschung
und -prüfung

Report

on Testing a Gasket Material for Reactivity with Oxygen

Reference Number	2-1891/2012 I E
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Customer	Flexitallic Ltd Scandinavia Mill Hunsworth Lane Cleckheaton, West Yorkshire BD19 4LN United Kingdom
Order Date	June 28, 2012
Reference	-
Receipt of Order	July 16, 2012
Test Samples	Gasket material Novus FI for use in flanged connections in piping, valves and fittings or other components for gaseous oxygen at temperatures greater than 60 °C; BAM-Order No. 2.1/51 162
Receipt of Samples	July 2, 2012
Test Date	October 16, 2012 to June 12, 2013
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: 2004-07 „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: September 2011; 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 4 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.

1 Documents and Test Samples

The following documents and samples were submitted to BAM:

1 Test Application
1 Material Data Sheet (5 pages, issued March 25, 2010)
15 Sheets gasket material Novus FI with steel reinforcement
Diameter: 140 mm; Thickness: 2 mm
Color: Grey

2 Test Methods

To test and evaluate the compatibility of Novus FI for use as gasket material in flanged connections in piping, valves and fittings or other components for gaseous oxygen service at temperatures up to 200 °C a determination of the autogenous ignition temperature (AIT), an investigation of the aging resistance and a flange test in high pressure oxygen were 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	31	83	> 500
2	31	82	> 500
3	31	83	> 500
4	31	83	> 500
5	31	82	> 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 = 31 bar. The final oxygen pressure p_F was approximately 83 °bar.

3.2 Artificial Aging

The test method is described in annex 2.

Results:

Time [h]	Temperature [°C]	Oxygen Pressure [bar]	Mass Change [%]
100	225	80	- 0.4

After aging of the test sample at 80 bar oxygen pressure and 225 °C, the test sample was apparently unchanged. The sample lost 0.4 % 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	31	81	> 500
2	31	82	> 500
3	31	82	> 500
4	31	83	> 500
5	31	82	> 500

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	80	200	Only those parts of the gasket burn that project into the pipe. The flange remains gas-tight.
2	80	200	same behavior as in test no. 1
3	80	200	same behavior as in test no. 1
4	80	200	same behavior as in test no. 1
5	80	200	same behavior as in test no. 1

In five tests at 80 bar oxygen pressure and 200 °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.

4 Summary and Evaluation

The tests have shown that the autogenous ignition temperature of the gasket material Novus FI is greater than 500 °C at 83 bar oxygen pressure.

At a temperature of 225 °C and an oxygen pressure of 80 bar, the gasket material Novus FI proved to be sufficient aging resistant. The sample lost 0.4 % in mass.

The tests have shown that the autogenous ignition temperature of the aged gasket material Novus FI is greater than 500 °C at 82 bar oxygen pressure. Therefore, neither the non-aged sample nor the aged sample ignites at temperatures up to 500 °C.

Generally, in evaluating nonmetallic materials for oxygen service, a safety margin of 50 °C between AIT and maximum operating temperature is being considered for safety reasons. As the maximum operating temperature is 200 °C, the gasket material Novus FI fulfills this requirement.

On basis of the test results and the pre-condition that any oxygen pressure impacts in valves and fittings or in other components for gaseous oxygen service are excluded, there are no objections with regard to technical safety, to use the gasket material Novus FI in flanged connections made of copper, copper alloys or steel at following operating conditions:

Maximum Temperature	Maximum Oxygen Pressure
200 °C	80 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 gasket material Novus FI for liquid oxygen service. For this application, a particular test for reactivity with liquid oxygen needs to be carried out.

5 Comments

The test results refer exclusively to the batch of the tested material.

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, August 29, 2013

Division 2.1
"Gases, Gas Plants"

On behalf of

Dipl.-Ing. P. Hartwig
Study Director "Safe Handling of Oxygen"

Copies:
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2. Copy: BAM - Division 2.1 "Gases, Gas Plants"

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 cm^3 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.

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.