Bundesanstalt für
Materialforschung
und -prüfung

Report
on Testing a Gasket Material for Reactivity with Oxygen

Reference Number	2-1911/2014 I E
Copy	1. Copy of 2 Copies
Customer	Frenzelit-Werke GmbH Frankenhammer 95456 Bad Berneck Germany
Order Date	July 31, 2014
Reference	EMP / BWI
Receipt of Order	August 7, 2014
Test Samples	Gasket material Novapress® Universal, undisclosed batch, for use in flanged connections in piping, valves and fittings or other components for gaseous oxygen service at 100 bar and 80 °C; BAM Order-No.: 2.1/52 217
Receipt of Samples	August 5, 2014
Test Date	September 17 to December 3, 2014
Test Location	BAM - Working Group "Safe Handling of Oxygen"; building no. 41, room no. 073
Test procedure 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 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 3.

TEST REPORT

1 Documents and Test Samples

The following documents and samples were submitted to BAM:

1 Test Application
15 Disks gasket material Novapress® Universal, undisclosed batch
Outer-Ø: 140 mm; Thickness: 3 mm

2 Test Methods

To test and evaluate the compatibility of the nonmetallic material Novapress® Universal, undisclosed batch, for use as a gasket in flanged connections in piping, valves and fittings or other components for gaseous oxygen service at 100 bar and 80 °C, a determination of the autogenous ignition temperature (AIT), an investigation of the aging resistance in high pressure oxygen, and a flange test were carried out.

3 Results

3.1 Autogenous Ignition Temperature (AIT)

According to the above-mentioned maximum operating pressure of Novapress® Universal, undisclosed batch, for use as a gasket material, the determination of the AIT was performed at approximately 100 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	72	102	139
2	72	100	137
3	72	101	141
4	72	104	148
5	72	102	138

In five tests with an initial oxygen pressure of p_I = 72 bar, an AIT of 141 °C was determined with a standard deviation of ± 4 °C. The oxygen pressure p_F at ignition is approximately 102 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 100 bar and at 105 °C. The test method is described in annex 2.

Results:

Time [h]	Temperature [°C]	Oxygen Pressure [bar]	Mass Change [%]
100	105	100	+ 2.4

After aging of the test sample at 105 °C and 100 bar, the test sample was extremely brittle. The sample gained 2.4 % 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	72	102	146
2	72	103	152
3	72	104	151
4	72	104	149
5	72	103	143

In five tests with an initial oxygen pressure of p_I = 72 bar, an AIT of 148 °C was determined with a standard deviation of ± 4 °C. The final oxygen pressure p_F at ignition is approximately 103 bar.

This shows, that the AIT of the aged sample is unchanged compared to the AIT of the non-aged sample within the precision of measurement.

3.3 Flange Test

According to the above-mentioned maximum operating conditions of Novapress® Universal, undisclosed batch, for use as a gasket, the flange test was performed at 100 bar oxygen pressure and at a temperature of 80 °C. The test method is described in annex 3.

Results:

Test No.	Oxygen Pressure [bar]	Temperature [°C]	Notes
1	100	80	Only those parts of the gasket burn that project into the pipe.
2	100	80	same behavior as in test no. 1
3	100	80	same behavior as in test no. 1
4	100	80	same behavior as in test no. 1
5	100	80	same behavior as in test no. 1

In five tests at 100 bar oxygen pressure and 80 °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

In five tests with an initial oxygen pressure of p_I = 72 bar, an AIT of 141 °C was determined with a standard deviation of ± 4 °C. The oxygen pressure p_F at ignition is approximately 102 bar.

After aging of the test sample at 100 bar oxygen pressure and 105 °C, the sample was extremely brittle and had gained 2.4 % in mass. The AIT of the aged sample, determined in five tests with an initial oxygen pressure of p_I = 72 bar, is 148 °C with a standard deviation of ± 4 °C. The oxygen pressure p_F at ignition is approximately 103 bar. This result shows that the AIT of the aged sample is unchanged compared to the AIT of the non-aged sample within the precision of measurement.

Brittleness and an increase in mass of more than 2 % of an aged sample show that the material is insufficient aging resistant. Because of these findings, the gasket can only be used for gaseous oxygen service, if dynamic stresses can safely be excluded. The detected increase in mass of the gasket has no impact on its technical safety; however, it may have an influence on its practical application in oxygen.

Generally, in evaluating gasket 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 80 °C, the gasket material Novapress® Universal, undisclosed batch, fulfills this criterion.

In five flange tests at 100 bar oxygen pressure and 80 °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.

On basis of these results and the above-mentioned restrictions, there are no objections with regard to technical safety to use the gasket material Novapress® Universal, undisclosed batch, with a maximum thickness of 3 mm in flange connections made of copper, copper alloys or steel at following conditions:

Maximum Oxygen Pressure [bar]	Maximum Temperature [°C]
100	80

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 Novapress® Universal, undisclosed batch, for liquid oxygen service. For this case, a particular test for reactivity with liquid oxygen needs to be carried out.

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.