Report

on Testing a Gasket Material for Reactivity with Oxygen

Reference Number	2-1327/2014 E
Copy	1. Copy of 2 Copies
Customer	Donit Tesnit d.o.o. Cesta komandanta Staneta 38 1215 Medvode Slovenija
Order Date	May 28, 2014
Receipt of Order	June 3, 2014
Test Samples	Gasket material Tesnit® BA-U, 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.: 2.1/52 128
Receipt of Samples	June 2, 2014
Test Date	June 20 to July 7, 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.

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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 (1 page, date of issue: unknown)
1 Safety Data Sheet (5 pages, date of issue 04/1-date October 1, 2010)
15 Disks gasket material Tesnit® BA-U, undisclosed batch
Diameter: 140 mm; Thickness: 2 mm
One side with imprint: Tesnit BA-U
Color: Blue

2 Test Methods

To test and evaluate the compatibility of the nonmetallic material Tesnit® BA-U, undisclosed batch, for use as a gasket material 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 at 100 bar and 80 °C, 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	75	109	155
2	75	109	155
3	75	107	144
4	75	109	152
5	75	109	152

In five tests with an initial oxygen pressure of p_I = 75 bar, an AIT of 152 °C was determined with a standard deviation of ± 5 °C. The oxygen pressure p_F at ignition is approximately 109 bar.

3.2 Artificial Aging

The test method is described in annex 2.

Results:

Time [h]	Temperature [°C]	Oxygen Pressure [bar]	Mass Change [%]
100	105	100	+ 5

After aging of the test sample at 100 bar oxygen pressure and 105 °C, the test sample was highly brittle. The sample gained 5.0 % 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	75	111	158
2	75	114	168
3	75	112	166
4	75	113	165
5	75	112	161

In five tests with an initial oxygen pressure of p_I = 75 bar, an AIT of 164 °C was determined with a standard deviation of ± 4 °C. The final oxygen pressure p_F at ignition is approximately 112 bar.

This shows, that the AIT of the aged sample is slightly greater than the AIT of the non-aged sample within the precision of measurement.

3.3 Flange Test

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 = 75 bar, an AIT of 152 °C was determined with a standard deviation of ± 5 °C. The oxygen pressure p_F at ignition is approximately 109 bar.

After aging of the test sample at 100 bar oxygen pressure and 105 °C, the sample was highly brittle. Therefore the gasket material may only be used for gaseous oxygen service, if dynamic stresses can safely be excluded. In addition, the unfavorable aging behavior may influence the practical application of the material. The sample gained 5.0 % in mass. This ascertained difference of mass has no influence on the application in oxygen, but it can also influence the practical application of the sealing material. In general, at a change of the sample mass of more than 2.0 %, the material proved to be insufficient aging resistant.

In five tests with an initial oxygen pressure of p_I = 75 bar, an AIT of 164 °C was determined with a standard deviation of ± 4 °C. The oxygen pressure p_F at ignition is approximately 112 bar. This shows, that the AIT of the aged sample is slightly greater than the AIT of the non-aged sample within the precision of measurement.

In five tests of the flange test 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 requirement, that the gasket material may only be used for gaseous oxygen service, if dynamic stresses can safely be excluded, there are no objections with regard to technical safety to use the gasket material Tesnit® BA-U, undisclosed batch, with a maximum thickness of 2 mm in flange connections made of copper, copper alloys or steel at following conditions:

Maximum Oxygen Pressure	Maximum Temperature
100 bar	80 °C

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

This evaluation does not cover the use of the gasket material Tesnit® BA-U, undisclosed batch, for liquid oxygen service. For this case, a particular test for reactivity with liquid oxygen needs to be carried out.

5 Comments

The test results only refer to the tested batch of Tesnit® BA-U.

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 20, 2014

Division 2.1
"Gases, Gas Plants"

On behalf of

Dipl.-Ing. Peter Hartwig

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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 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.