BAM
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TEST REPORT

On Testing a Nonmetallic Material for Reactivity with Gaseous Oxygen

BAM reference	15021893 E
Copy	1st copy of 2 copies
Customer	TEADIT Deutschland GmbH Schanzenstraße 35 51063 Köln
Order date	April 16, 2015
Receipt of order	April 17, 2015
Test samples	Sealing material TEADIT 24 SH, batch 0300021644; BAM Order-No.: 2.1/52 617
Receipt of samples	June 4, 2015
Test date	September 14 to December 2, 2015
Test location	BAM - Working Group "Safe Handling of Oxygen"; building no. 41, room no. 073
Test procedure according to	ISO 21010:2014 and DIN EN 1797:2002-02 "Cryogenic Vessels - Gas/Material Compatibility" Annex of code of practice M 034-1 (BGI 617-1) "List of nonmetallic materials compatible with oxygen", 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
Safety Related Maximum Operating Conditions	See chapter 4 "Summary and Evaluation"

All pressures of this report are excess pressures.
This test report consists of page 1 to 6 and annexes 1 to 3.

1 Documents and Test Samples

The following documents and samples were submitted to BAM:

1 Test application
"Testing and evaluating the compatibility of the sealing material TEADIT 24 SH, batch 0300021644, for use as a gasket for gaseous oxygen service at temperatures up to 200 °C and at pressures up to 30 bar."

1 Safety Data Sheet
(5 pages, TEADIT 24 SH, Rev.: 05/20012014)

1 Material Data Sheet
(2 Pages, TEADIT 24 SH, 01/121013)

16 Disks
of the sealing material TEADIT 24 SH, batch 0300021644,
Outer-Ø: 140 mm; Thickness: 3 mm
Color of the sealing material: White

2 Test Methods

To evaluate the compatibility of the nonmetallic material TEADIT 24 SH, batch 0300021644, for use as a gasket in gaseous oxygen service at temperatures up to 200 °C and at pressures up to 30 bar, a determination of the autogenous ignition temperature (AIT), an investigation of the aging resistance, and a flange test were carried out.

Tests on ignition sensitivity to gaseous oxygen impacts were not carried out. According to the costumer, oxygen pressure impacts can be safely excluded in the intended service.

3 Results

3.1 Autogenous Ignition Temperature (AIT)

Based on the specified maximum operating conditions, the AIT test was performed at a final oxygen pressure of approximately 30 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	13	34	474
2	13	35	480
3	13	35	482
4	13	35	481
5	13	35	480

In five tests with an initial oxygen pressure of p_I = 13 bar, an AIT of 479 °C was determined with a standard deviation of ± 3 °C. The final oxygen pressure p_F at ignition is approximately 35 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 225 °C and at 30 bar. The test method is described in annex 2.

Results:

Time [h]	Temperature [°C]	Oxygen Pressure [bar]	Mass Change [%]
100	225	30	0

After aging of the test sample at 225 °C and at 30 bar oxygen pressure, the test sample was apparently unchanged. The mass of the test sample did not change.

3.2.1 AIT after Artificial Aging

The same test conditions as in chapter 3.1 were used for determining the AIT after 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	13	35	483
2	13	35	476
3	13	35	481
4	13	35	481
5	13	35	478

In five tests with an initial oxygen pressure of p_I = 13 bar, an AIT of 480 °C was determined with a standard deviation of ± 3 °C. The final oxygen pressure p_F at ignition is approximately 35 bar. These results show 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

Based on the specified maximum operating conditions, flange testing was performed at 30 bar oxygen pressure and at a temperature of 200 °C. The test method is described in annex 3.

Results:

Test Number	Oxygen Pressure [bar]	Temperature [°C]	Notes
1	30	200	The gasket burns partly between the flange faces. The flange connection remains gas-tight. The thickness of the gasket is approximately 1.4 mm in the range of the sealing face.
2	30	200	same behavior as in test no. 1
3	30	200	Prior to pressurizing the heated flange connection with gaseous oxygen, it had been repeatedly tightened by a torque wrench with a torque of 200 Nm. Only those parts of the gasket burn that project into the pipe, the flange connection remains gas-tight. The thickness of the gasket is approximately 1 mm in the range of the sealing face.
4	30	200	same behavior as in test no. 3
5	30	200	same behavior as in test no. 3
6	30	200	same behavior as in test no. 3
7	320	200	same behavior as in test no. 3

In the first both tests, the gaskets burnt partly between the flange faces. The flange connections remained gas-tight and the fire did not kindle the metallic material of the pipe. The thicknesses of the two gaskets were approximately 1.4 mm in the range of the sealing face.

Taking into account these results, the heated flange connection was tightened by a torque wrench (torque 200 Nm) prior to pressurizing with gaseous oxygen. In five tests at 30 bar oxygen pressure and 200 °C, only those parts of the gaskets burnt that project into the pipe. The fire was neither transmitted to the steel nor the gaskets burnt between the flanges. The flange remained gas-tight. The thicknesses of the gaskets were approximately 1 mm in the range of the sealing face.

4 Summary and Evaluation

The AIT of the sealing material TEADIT 24 SH, batch 0300021644, was 479 °C at 35 bar oxygen pressure with a standard deviation of ± 3 °C.

At a temperature of 225 °C and an oxygen pressure of 30 bar, the sealing material TEADIT 24 SH, batch 0300021644, proved to be aging resistant. The mass of the test sample did not change.

The tests showed that the AIT of the aged sealing material TEADIT 24 SH, batch 0300021644, was 480 °C at 35 bar oxygen pressure. Hence, the AIT is unchanged compared to the AIT of the non-aged sample within the precision of measurement.

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 sealing material TEADIT 24 SH, batch 0300021644, fulfills this criterion.

Tests on TEADIT 24 SH that had been performed already in 2005 – BAM Test Report II-1492/ 2005 of October 27, 2005 – showed that that the batch and thickness of the sealing material, the torque of the flange bolts, as well as the test temperature and pressure had an influence on the test result in the flange test.

The same applies to the tests that were carried out on batch 0300021644 of TEDIT 24 SH. The sealing material passed the test only after the torque of the flange bolts had been increased to 200 Nm and retightening of the bolts took place prior to pressurizing the tester with oxygen.

On basis of these facts and the test results, there are no objections regarding technical safety to use the sealing material TEADIT 24 SH, batch 0300021644, as gasket with a maximum thickness of 3 mm in flanged connections of piping, valves and fittings or other components with tongue and groove. This applies to flange connections made of copper, copper alloys, or steel in gaseous oxygen service at following conditions:

Maximum Temperature [°C]	Maximum Oxygen Pressure [bar]
200	30

Flange testing of the gasket has shown that that the sealing material TEADIT 24 SH, batch 0300021644, is not suitable for flat face flanges and male/female flanges.

5 Comments

This evaluation is based exclusively on the results of the tested batch of the sealing material TEADIT 24 SH.

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.

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January 6, 2016

Division 2.1 „Gases, Gas Plants"

By order

Dipl.-Ing. Peter Hartwig

Distribution list: 1st copy: TEADIT Deutschland GmbH
2nd 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 initial pressure p_I 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 the final pressure p_F.

It is important to know the oxygen pressure p_F, 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.