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Translation of BAM Report

about the test of nonmetallic materials
for reactivity with oxygen

Reference Number	2-1073/2014 I
Copy	1. Copy of 2 Copies
Customer	TEADIT Deutschland GmbH Schanzenstraße 35 51063 Cologne Germany
Oder Date	April 29, 2014
Receipt of Order	April 30, 2014
Test Samples	Teadit **TF 1580**, Batch 111749/035/02/114, to be applied as a flat gasket in flange connections at oxygen pipe, equipment and valves for gaseous oxygen up to 250°C; BAM-Order-Nr. 2.1/52 084
Receipt of Samples	May 06, 2014
Test Date	May 26 up to June 10, 2014
Test Location	BAM – working area “Safe handle with oxygen; Building no.41, room no. 073
Test Procedure	DIN EN 1797:2002-02
According to	“Cryogenic Vessels – Gas/Material Compatibility” ISO 21010: 2004-07 Annex of supporting document to code of practice M 034-1 “Oxygen” (BGI 617-1) “List of nonmetallic materials” Edition: March 2014 According to rule BGR 500 “Betreiben von Arbeitsmittel” part 2, Chapter 2.32 “Betreiben von Sauerstoffanlagen“, Chapter 3.17 „Gleitmittel und Dichtwerkstoffe“ Edition: June 2013

All pressures in this report are excess pressures (gage pressures). This test report consist of page 1 to 5 and annex 1 to 3.

1. Documents and Test Samples

The following documents and samples were submitted to BAM:

1 test application
1 Product information TF1580 (No. 01/121013),
15 test sample Teadit TF 1580; Diameter 140 mm; 3 mm Thickness
Color: White

2. Test Methods

For the evaluation of TEADIT TF 1580 in oxygen service equipment were performed a flange test up to 250 °C, an autogenous ignition temperature, an aging test and an autogenous ignition temperature after aging.

3. Test results

3.1. Autogenous Ignition Temperature (AIT)

The tests method is described in annex 1.

Results

Test No.	Oxygen pressure p_a [bar]	Oxygen pressure p_e [bar]	AIT [°C]
1	33	87	485
2	33	85	479
3	33	87	486
4	33	86	486
5	33	87	483

In five tests with an oxygen pressure of pa = 33 bar, an AIT of 484 °C was determined with a standard deviation of 3 °C. The oxygen pressure pe at ignition is approximately 87 bar.

3.2. Artificial Aging

The test method is described in annex 2.

Results:

Time [h]	Temperature [°C]	Pressure [bar]	Mass change [%]
100	275	83	0

After aging of Teadit TF1580 at 275 °C and 83 bar oxygen pressure, the material was apparently unchanged. The mass of the test sample did not change.

3.2.1. Autogenous Ignition Temperature (AIT) after Artificial Aging

The tests method is described in annex 1.

Results

Test No.	Oxygen pressure p_a [bar]	Oxygen pressure p_e [bar]	AIT [°C]
1	33	85	479
2	33	85	480
3	33	85	485
4	33	85	480
5	33	85	482

In five tests with an oxygen pressure of p_a = 33 bar, an AIT of 481 °C was determined with a standard deviation of 2 °C for the aged TF 1580. The oxygen pressure p_e at ignition is approximately 86 bar.

3.3. Flange Test

The test method is described in annex 3.

Results:

Test No.	Temperature [°C]	Oxygen pressure [bar]	Notes
1	250	83	Only those parts of the gasket burn that project into the pipe
2	250	83	Same result as in test no. 1
3	250	83	Same result an in test no. 1
4	250	83	Same result as in test no. 1
5	250	83	Same results as in test no. 1

In five tests at 83 bar oxygen pressure and 250 °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 flange. The flange remains gas-tight.

4. Evaluation

The tests have shown that the autogenous ignition temperature of the material is 484 °C (±3 °C) at 87 bar.

At a temperature of 275 °C and an oxygen pressure of 83 bar, the material proved to be sufficient aging resistant.

The aged TF 1580 has at an oxygen pressure of 86 bar an ignition temperature of 481 °C (±2 °C).

This shows that the results of the aged material are in the metering precision.

On basis of those test results and the results of the flange testing, there are no objections with regard to technical safety to use the gasket TEADIT TF 1580 in flange connections made of cooper, cooper alloys or steel at following conditions:

Maximum temperature	Maximum oxygen pressure
250 °C	83 bar

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

This report does not cover the use of the materials Teadit TF 1580 for liquid oxygen service. For this application, a particular test for reactivity with liquid oxygen needs to be carried out.

Comments

The test results refer exclusively to the tested material.

Products that have been tested by us, and which are on the market, shall be marked according to our evaluation in the BAM test report. A label on a product saying that a BAM test has been performed and (or) citing our reference number, only, is not tolerable. The use of the product and its safe operating conditions must also be given.

It shall be clear that the product may 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.

Annex 1

Testing for Autogenous Ignition Temperature

To perform the test, solid samples are divided and liquid samples onto ceramic fibers. An autoclave with a volume of 34 cm^3 contains usually a sample mass of approximately 0.2 g to 0.5 g. A low-frequency heater allows to heat the sample inductively in an almost linear way at a rate 110 °C/min.

The temperature is monitored by means of a thermocouple at the sample. The pressure is measured by means of a pressure transducer. The ignition of the sample can be recognized by a sudden rise in temperature and pressure.

The maximum use temperature of a material is fixed at a value that is 100 °C below the determined autogenous ignition temperature (AIT). This safety margin considers the fact that the AIT is not a constant and depends on tester configuration, sample preparation, and other parameters. Publications in literature as well as researches in BAM confirm these facts.

The safety margin 100 °C has been proven over many decades.

Experience shows that an investigation of the AIT is not necessary for materials at use temperature up to 60 °C. In this case, the test results of other here mentioned tests need to be considered for technical safety evaluation.

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 consist of two DN 65 PN 160 steel pipes, each approximately 1 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 temperature, at least 50 K lower than the ignition temperature of the gasket. An electrical filament ignites that part of the gasket projection 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) are 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.