Bundesanstalt für Materialforschung und -prüfung

Report

on Testing a Gasket Material for Reactivity with Oxygen

Reference Number 2-484/2014 E

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Customer

Triangle Fluid Controls Ltd.
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PO Box 186
Belleville, ON, K8N 5S7
Kanada

Order Date February 14, 2014

Reference Purchase Order No.: CHETT-021414

Receipt of Order February 20, 2014

Test Samples Durlon 9200 white, undisclosed batch number for use as a gasket material in flanged connections in piping, valves and fittings or other components for gaseous oxygen service up to 52 bar and temperatures up to 260 °C and for liquid oxygen service;
BAM Order-No.: 2.1/51 975

Receipt of Samples February 20, 2014

Test Date February 28 to March 18, 2014

Test Location BAM - Working Group "Safe Handling of Oxygen"; building no. 41, room no. 120

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 2013;

Rule BGR 500 "Betreiben von Arbeitsmitteln" part 2,
chapter 2.32 "Betreiben von Sauerstoffanlagen",
paragraph 3.17 "Sealing materials and sealing materials",
Edition: April 2008.

All pressures of this report are excess pressures.
This test report consists of page 1 to 5 and annex 1 to 4.

1 Documents and Test Samples

The following documents and samples were submitted to BAM:

1 Test application
1 Material Safety Data Sheet Durlon 9200, REV 2013-3
15 Disks Durlon 9200, undisclosed batch number
Outer Diameter 140 mm, Thickness 3 mm
Color: White

2 Test Methods

To evaluate the compatibility of Durlon 9200, undisclosed batch number, for use as a gasket material in piping, valves and fittings or other components for gaseous oxygen service at temperatures up to 260 °C, a determination of the autogenous ignition temperature (AIT), an investigation of the aging resistance in high pressure oxygen, and a flange test at 52 bar and 260 °C were carried out.

The compatibility of the material with liquid oxygen was tested by its reactivity with liquid oxygen on mechanical impact.

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	21	54	472
2	21	54	463
3	21	55	468
4	21	55	467
5	21	55	468

In five tests with an initial oxygen pressure of p_I = 21 bar, an AIT of 468 °C was determined with a standard deviation of ± 3 °C. The oxygen pressure p_F at ignition is approximately 55 bar.

3.2 Artificial Aging

The test method is described in annex 2.

Results:

Time [h]	Temperature [°C]	Oxygen Pressure [bar]	Mass Change [%]
100	285	52	- 0.1

After aging of the test sample at 52 bar oxygen pressure and 285 °C, the test sample was apparently unchanged and lost 0,1 % in mass.

3.3 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	21	53	459
2	21	54	461
3	21	54	466
4	21	55	465
5	21	55	467

In five tests with an initial oxygen pressure of p_I = 21 bar, an AIT of 464 °C was determined with a standard deviation of ± 3 °C. The oxygen pressure p_F at ignition is approximately 54 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.

3.4 Flange Test

The test method is described in annex 3.

Results:

Number of Tests	Oxygen Pressure [bar]	Temperature [°C]	Notes
1	52	260	Only those parts of the gasket burn that project into the pipe.
2	52	260	same behavior as in test no. 1
3	52	260	same behavior as in test no. 1
4	52	260	same behavior as in test no. 1
5	52	260	same behavior as in test no. 1

In five tests at 52 bar oxygen pressure and 260 °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.

3.5 Reactivity with Liquid Oxygen on Mechanical Impact

The test method is described in annex 4.

Results:

Test No.	Drop Heights [m]	Impact Energy [Nm]	Reaction
1	1.00	750	ignition on 5. impact
2	0.83	625	ignition on 6. impact
3	0.67	500	no reaction
4	0.67	500	no reaction
5	0.67	500	no reaction
6	0.67	500	no reaction
7	0.67	500	no reaction
8	0.67	500	no reaction
9	0.67	500	no reaction
10	0.67	500	no reaction
11	0.67	500	no reaction
12	0.67	500	no reaction

At a drop height of 0.67 m (impact energy 500 Nm), in ten separate tests, no reaction of the test sample with liquid oxygen could be detected.

4 Summary and Evaluation

The tests have shown that the autogenous ignition temperature of the gasket material Durlon 9200, undisclosed batch number, is 468 °C at 55 bar oxygen pressure. The standard deviation of the AIT is ± 3 °C.

After aging of the test sample at 52 bar oxygen pressure and 285°C, the test sample was apparently unchanged and lost 0.1 % in mass.

The tests have shown that the autogenous ignition temperature of the aged gasket material Durlon 9200, undisclosed batch number, is 464 °C at 54 bar oxygen pressure. The standard deviation of the AIT is ± 3 °C.

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.

For safety reasons a safety margin of 100 °C between AIT and maximum operating temperature is being considered in evaluating nonmetallic materials for oxygen service. As the maximum operating temperature is 260 °C, the sample of the gasket material Durlon 9200, undisclosed batch number, fulfills this criterion.

On basis of the test results and the results of the flange testing, there are no objections with regard to technical safety to use the gasket material Durlon 9200 white in flange connections made of copper, copper alloys or steel at following conditions:

Maximum Oxygen Pressure	Maximum Temperature
up to 52 bar	up to 260 °C

This applies to flat face flanges, male/female flanges, and flanges with tongue and groove. According to the BAM-Standard "Testing for Reactivity with Liquid Oxygen on Mechanical Impact", described in annex 4, there are no objections with regard to technical safety to use the gasket material Durlon 9200, undisclosed batch number, in valves and fittings or other components for liquid oxygen service. In this case, a limitation to a particular pressure range is not necessary as compression of liquid oxygen causes no significant change in concentration and therefore has no considerable influence on the reactivity of the gasket material.

5 Comments

This evaluation is based exclusively on the test results of the gasket material Durlon 9200, undisclosed batch number.

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 and liquid 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, May 9, 2014

Division 2.1
"Gases, Gas Plants"

On behalf of

Dr. Thomas Kasch

Distribution list:
1. Copy: Triangle Fluid Controls Ltd.
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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.

Annex 4

Testing for Reactivity with Liquid Oxygen on Mechanical Impact

Approximately 0.5 g of the liquid or divided sample is placed into a sample cup (height = 10 mm; diameter = 30 mm), made of 0.01 mm copper foil. Liquid oxygen is poured into the cup over the sample which is then exposed to the mechanical impact of a plummet (mass = 76.5 kg). The drop height of the plummet can be varied. A steel anvil with a chrome/nickel steel plate supports the sample cup. The anvil, having a mass eight times of the plummet, is supported by four damping elements mounted on the steel frame of the test apparatus that rests on a concrete base.

A reaction of the sample with liquid oxygen is usually indicated by a flame and a more or less strong noise of an explosion. The impact energy, at which no reaction occurs, is determined in varying the drop height of the plummet. This result shall be confirmed in a series of ten consecutive tests under the same conditions. The tests are finished, if reactions can be observed at impact energies of 125 Nm or less (equivalent to a drop height of the plummet of 0.17 m or less). In this case, with regard to technical safety, the material is not suitable for liquid oxygen service.