

## Report

on Testing a nonmetallic Material for Reactivity with Oxygen

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| <b>Reference Number</b>                           | 2-1033/2014 E  |
| <b>Copy</b>                                       | 1. Copy of 2 Copies  |
| <b>Customer</b>                                   | Chesterton International GmbH<br>Am Lenzenfleck 23<br>85737 Ismaning   |
| <b>Order Date</b>                                 | April 25, 2014   |
| <b>Receipt of Order</b>                           | April 28, 2014   |
| <b>Test Samples</b>                               | Thread seal tape Chesterton 800 GoldEnd Band,<br>undisclosed batch, for gaseous oxygen service at<br>temperatures up to 100 °C;<br>BAM Order-No.: 2.1/52 077   |
| <b>Receipt of Samples</b>                         | May 6, 2014  |
| <b>Test Date</b>                                  | May 27, 2014 to June 12, 2014  |
| <b>Test Location</b>                              | BAM - Working Group "Safe Handling of Oxygen";<br>building no. 41, room no. 120  |
| <b>Test Procedure or Requirement According to</b> | DIN EN 1797: 2002-02<br>„Cryogenic Vessels - Gas/Material Compatibility“<br>ISO 21010: 2004-07<br>„Cryogenic Vessels - Gas/Material Compatibility“<br>Annex of pamphlet M 034-1 (BGI 617-1)<br>“List of nonmetallic materials compatible with oxygen by BAM<br>Federal Institute for Material Research and Testing.”, by<br>German Social Accident Insurance Institution for the raw<br>materials and chemical industry,<br>Edition: March 2014;<br>TRGS 407 Technical Rules for Hazardous Substances<br>“Tätigkeiten mit Gasen - Gefährdungsbeurteilung”<br>chapter 3 “Informationsermittlung und<br>Gefährdungsbeurteilung” and<br>chapter 4 “Schutzmaßnahmen bei Tätigkeiten mit Gasen”<br>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.

TEST REPORT



## 1 Documents and Test Samples

The following documents and samples were submitted to BAM:

- 1 Test Application
- 1 Safety Data Sheet No. 127-14  
(6 pages, version: December 12, 2014)
- 1 Material Data Sheet  
(2 pages, version 12/07)
- 10 Coils of Chesterton 800 GoldEnd Band, undisclosed batch  
Width: 6 mm, Thickness: 0.1 mm  
Color: white

## 2 Test Methods

To evaluate the compatibility of the thread seal tape Chesterton 800 GoldEnd Band, undisclosed batch, for gaseous oxygen service at temperatures up to 100 °C the ignition sensitivity to gaseous oxygen impacts at 60 °C and at 100 °C, a determination of the autogenous ignition temperature (AIT) and an investigation of the aging resistance in high pressure oxygen were carried out.

## 3 Results

### 3.1 Ignition Sensitivity to Gaseous Oxygen Impacts

The test method is described in annex 1.

Results:

| Sample Temperature<br>$t_a$ [°C] | Initial Oxygen Pressure<br>$p_I$ [bar] | Final Oxygen Pressure<br>$p_F$ [bar] | Reaction on Impact    |
|----------------------------------|--|--------------------------------------|-----------------------|
| 60                               | 1                                      | 30                                   | no reaction*          |
| 60                               | 1                                      | 40                                   | ignition on 4. impact |
| 60                               | 1                                      | 30                                   | no reaction*          |
| 100                              | 1                                      | 30                                   | no reaction*          |
| 100                              | 1                                      | 30                                   | no reaction*          |

\* within a series of five consecutive impacts

In two separate tests, each consisting of a series of five consecutive impacts, no reactions of the thread seal tape Chesterton 800 GoldEnd Band, undisclosed batch, with oxygen could be observed at a final oxygen pressure  $p_F$  of 30 bar and at temperatures of 60 °C and 100 °C.

### 3.2 Autogenous Ignition Temperature (AIT)

The test method is described in annex 2.

Results:

| Test No. | Initial Oxygen Pressure<br>$p_i$ [bar] | Final Oxygen Pressure<br>$p_F$ [bar] | AIT<br>[°C] |
|----------|--|--------------------------------------|-------------|
| 1        | 12                                     | 32                                   | 470         |
| 2        | 12                                     | 32                                   | 472         |
| 3        | 12                                     | 32                                   | 475         |
| 4        | 12                                     | 32                                   | 469         |
| 5        | 12                                     | 32                                   | 475         |

In five tests with an initial oxygen pressure of  $p_i = 12$  bar, an AIT of 472 °C was determined with a standard deviation of  $\pm 3$  °C. The oxygen pressure  $p_F$  at ignition is 32 bar.

### 3.3 Artificial Aging

The test method is described in annex 3.

Results:

| Time<br>[h] | Temperature<br>[°C] | Oxygen Pressure<br>[bar] | Mass Change<br>[%] |
|-------------|---------------------|--------------------------|--------------------|
| 100         | 125                 | 30                       | $\pm 0$            |

After aging of the thread seal tape Chesterton 800 GoldEnd Band, undisclosed batch, at 30 bar oxygen pressure and 125 °C, the test sample was apparently unchanged. The mass of the test sample did not change.

#### 3.3.1 AIT after Artificial Aging

The test method is described in annex 2.

Results:

| Test No. | Initial Oxygen Pressure<br>$p_i$ [bar] | Final Oxygen Pressure<br>$p_F$ [bar] | AIT<br>[°C] |
|----------|--|--------------------------------------|-------------|
| 1        | 12                                     | 31                                   | 449         |
| 2        | 12                                     | 31                                   | 451         |
| 3        | 12                                     | 32                                   | 464         |
| 4        | 12                                     | 32                                   | 465         |
| 5        | 12                                     | 32                                   | 467         |

In five tests with an initial oxygen pressure of  $p_i = 12$  bar, an AIT of 459 °C was determined with a standard deviation of  $\pm 8$  °C. The final oxygen pressure  $p_F$  at ignition is approximately 32 bar.

This shows, that the AIT of the aged sample is slightly lower compared to the AIT of the non-aged sample.

#### 4 Summary and Evaluation

The tests have shown that the autogenous ignition temperature of the thread seal tape Chesterton 800 GoldEnd Band, undisclosed batch, is 472 °C at 32 bar oxygen pressure. The standard deviation of the AIT is  $\pm 3$  °C.

At a temperature of 125 °C and an oxygen pressure of 30 bar, the thread seal tape Chesterton 800 GoldEnd Band, undisclosed batch, proved to be sufficient aging resistant. The mass of the test sample did not change.

The tests have shown that the autogenous ignition temperature of the aged thread seal tape Chesterton 800 GoldEnd Band, undisclosed batch, is 459 °C at approximately 32 bar oxygen pressure. The standard deviation of the AIT is  $\pm 8$  °C. This shows, that the AIT of the aged sample is slightly lower compared to the AIT of the non-aged sample.

Generally, in evaluating nonmetallic materials for oxygen service, a safety margin of 100 °C between AIT and maximum operating temperature is being considered for safety reasons. As the maximum operating temperature of is 100 °C, the thread seal tape Chesterton 800 GoldEnd Band, undisclosed batch, fulfills this criterion.

According to DIN EN 1797: 2002-02 „Kryo-Behälter - Verträglichkeit von Gas/Werkstoffen“ and to ISO 21010: 2004-07 „Cryogenic Vessels - Gas/Material Compatibility“ the criterion for a positive reaction of the sample to gaseous oxygen impacts is a temperature rise of at least 20 °C.

On basis of the above-mentioned criterion and the test results, there are no objections with regard to technical safety, to use the thread seal tape Chesterton 800 GoldEnd Band, undisclosed batch, for gaseous oxygen service at following operating conditions:

| Maximum Temperature<br>[°C] | Maximum Oxygen Pressure<br>[bar] |
|-----------------------------|----------------------------------|
| 100                         | 30                               |

This evaluation does not cover the use of the thread seal tape Chesterton 800 GoldEnd Band, 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 refer exclusively to the tested batch of the thread seal tape Chesterton 800 GoldEnd Band.

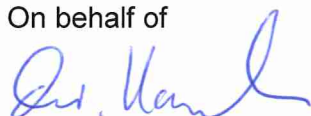
Products on the market that contain a reference to BAM testing shall be marked accordingly. It shall be evident that only a sample of a batch has been tested and evaluated for oxygen compatibility. The reference shall not produce a presumption of conformity that monitoring of the production on a regular 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, June 26, 2014**

**Division 2.1  
"Gases, Gas Plants"**

On behalf of



Dr. Thomas Kasch

Copies:           1. Copy: Chesterton International GmbH  
                      2. Copy: BAM – Division 2.1 "Gases, Gas Plants"

## Annex 1

### Testing for Ignition Sensitivity to Gaseous Oxygen Impacts

Approximately 0.2 g to 0.5 g of the pasty or divided solid sample is placed into a heatable steel tube, 15 cm<sup>3</sup> in volume. In case of liquids to be tested, ceramic fibre, soaked with the sample, is used. The sample tube is connected by a 750 mm long pipe (internal diameter 14 mm) and a pneumatically operated quick opening valve to a high-pressure oxygen accumulator.

A heater allows to set the sample tube to the test temperature  $t_a$ . After the tube and pipe are at test pressure  $p_a$ , the quick opening valve is opened and preheated oxygen of 60 °C and of pressure  $p_e$  flows abruptly into the pipe and tube. In this way, the oxygen in the tube and in the pipe is almost adiabatically compressed from pressure  $p_a$  to  $p_e$  and heated. If there is a reaction of the sample with oxygen, indicated by a steep temperature rise in the tube, further tests with a new sample are performed at a lower pressure ratio  $p_e/p_a$ . If, however, no reaction of the sample with oxygen can be detected after a waiting period of 30 seconds, the tube is de-pressurized and the test is repeated (up to four times) until a reaction takes place. This means, each test series consists of a maximum of five single tests with the same material under the same conditions. If no reaction can be observed, even after the fifth single test of a test series, testing is continued with new samples at greater pressure ratios  $p_e/p_a$ , until finally that pressure ratio is determined, at which no reaction can be observed within a test series of five single tests. If the repetition of that test series with a new sample shows the same result, the test can be finished or continued at a different test temperature  $t_a$ .

## Annex 2

### 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<sup>3</sup> 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 3**

### **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.