Bundesanstalt für
Materialforschung
und -prüfung

TEST REPORT

ON TESTING A NONMETALLIC MATERIAL FOR OXYGEN COMPATIBILITY

BAM reference	23040707-II-E
Copy	1st copy of 2
Customer	GEMÜ Gebr. Müller GmbH & Co. KG Fritz-Müller-Straße 6 - 8 74653 Ingelfingen-Criesbach Germany
Order date	December 11, 2023
Reference	Order: 912644 (dated December 20, 2023), Herbert Biegel
Receipt of order	December 11, 2023
Test samples	EPDM-based sealing material Code 17, batch EM6001
Receipt of samples	December 15, 2023
Test date	December 15, 2023, to February 6, 2024
Test location	BAM, Division 2.1 "Safety of Energy Carriers"; building no. 41; Unter den Eichen 87, 12205 Berlin, Germany
Test procedure according to	DIN EN 1797 und ISO 21010 "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 TRGS 407 Technical Rules for Hazardous Substances "Tätigkeiten mit Gasen - Gefährdungsbeurteilung" Chapter 3 "Informationsermittlung und Gefährdungsbeurteilung" and Chapter 4 "Schutzmaßnahmen bei Tätigkeiten mit Gasen"

This test report consists of page 1 to 5 and enclosure 1.

1 Documents and Test Samples

The following documents and samples were submitted to BAM:

1 Test application
Safety-related investigation on EPDM-based sealing material Code 17, batch EM6001, for use in gaseous oxygen service at temperatures up to 60 °C

1 GEMÜ REACH SVHC Reporting (4 pages, Fa. GEMÜ, Oktober 2022)

1 Safety Data Sheet IC EM6001
(7 pages, Fa. INTERCARAT, Revision Date: 2020/09/04)

1 Spezifikationsblatt (Specification sheet) Datenblatt EPDM IC EM 6001
(1 page, Fa. INTERCARAT, 10.06.2008)

1 Costumer Master Data Sheet (CMDS) (October 27, 2023)

5 Membranes of the EPDM-based sealing material Code 17, batch EM6001
Dimension: 62 x 67 mm, Thickness: 6.5 mm
Color: Black

2 Applied Test Methods

The EPDM-based sealing material Code 17, batch EM6001, shall be used in gaseous oxygen service at temperatures up to 60 °C.

The following test method was applied:

2.1 Testing for Ignition Sensitivity to Gaseous Oxygen Impacts

Generally, this test method is required if rapid oxygen pressure changes, so-called gaseous oxygen impacts, on the material cannot be safely excluded in usage.

3 Sampling

The material sample used for the investigation was provided by the customer.

3.1 Preparation of Samples

For testing, the EPDM-based sealing material Code 17, batch EM6001, was cut into parts of ca. 1 mm to 2 mm in edge length and was used in this form.

4 Tests

4.1 Testing for Ignition Sensitivity to Gaseous Oxygen Impacts

The test method is described in enclosure 1. Based on the specified maximum use temperature by the customer, the test was performed at 60 °C.

4.1.1 Assessment Criterion

According to DIN EN 1797 "Cryogenic Vessels - Gas/Material Compatibility" and to ISO 21010 "Cryogenic Vessels - Gas/Material Compatibility" the criterion for a reaction of the sample to gaseous oxygen impacts is a temperature rise of at least 20 °C.

If the sample exhibits a change in color, or in consistency after testing, this is also considered as a positive reaction by BAM for safety reasons, even if there is no temperature rise detectable of at least 20 °C.

4.1.2 Results

In each of the test series, the initial oxygen pressure p_I was at ambient pressure.

Sample Temperature t_i [°C]	Final Oxygen Pressure p_F [bar]	Reaction
60	25	on 1st impact
60	20	no*
60	20	on 3rd impact
60	15	no*
60	15	no*

* Within a series of five consecutive impacts

In two separate test series, each consisting of a series of five consecutive impacts, no reaction of the EPDM-based sealing material Code 17, batch EM6001, with oxygen could be observed at following conditions:

Sample Temperature t_i [°C]	Final Oxygen Pressure p_F [bar]
60	15

5 Summary of the Test Results

No reaction of the sample with oxygen could be observed at final pressures of 15 bar at a temperature of 60 °C.

6 Measurement uncertainty

The tests are carried out in accordance with the standards or guidelines indicated on the cover sheet of this report. Thereafter, the temperature measurement should have a maximum deviation of ± 2 K and the pressure measurement should have a maximum deviation of ± 2 bar.

For the test in chapter 4.1, the uncertainty is 1.7 K (according to the calibration protocol from January 9, 2023) for the temperature measuring system, and the uncertainty is 0.16 bar (according to the calibration protocol from December 7, 2023) for the used pressure measuring system.

7 Statements of conformity

The tests are carried out in accordance with the standards or guidelines, stated on the cover sheet of this report. Deviating or supplementary test criteria are described in the respective subchapter "Assessment Criterion" in Chapter 4 "Tests".

8 Opinion and Interpretation

The EPDM-based sealing material Code 17, batch EM6001, shall be used in gaseous oxygen service at temperatures up to 60 °C.

On basis of the test results, the requirements for sealing materials, described in the code of practice M034, annex 2 of code of practice M034-1, Technical Rules for Hazardous Substances TRGS 407 and based on the assessment criteria described in this test report, there are no objections regarding technical safety, to use the EPDM-based sealing material Code 17, batch EM6001, in gaseous oxygen service at following use conditions only:

Maximum Temperature [°C]	Maximum Oxygen Pressure [bar]
60	15

The content of the test report refers exclusively to the test sample of the EPDM-based sealing material Code 17, batch EM6001.

The product may be used in gaseous oxygen service only. The maximum safe oxygen pressure of the product and its maximum use temperature as well as other restrictions in use shall be given.

9 Comments

This safety-related investigation of the material considers the fact, that rapid oxygen pressure changes - so-called oxygen pressure surges – cannot be safely excluded in usage. In addition, the safety related investigation considers the fact, that the material shall be used in gaseous oxygen service at temperatures up to 60 °C, only.

Our experience shows that the safety characteristics of a product may vary from batch to batch. Therefore, today, we recommend batch testing of products, that are included for oxygen service. In this context, we would like to mention our paper from September 2009: "The Importance of Quality Assurance and Batch Testing on Nonmetallic Materials Used for Oxygen Service", Journal of ASTM International, Vol. 8th; Paper ID JAI102309. This publication can be purchased at www.astm.org.

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.

Bundesanstalt für Materialforschung und -prüfung (BAM)
12200 Berlin

February 9, 2024

Division 2.1 "Safety of Energy Carriers"

by order

Dr. Thomas Kasch	Dr. Martin Schmidt
Study Director	Deputy Head of Division

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Enclosure

Enclosure 1

Testing Nonmetallic Materials for Ignition Sensitivity to Gaseous Oxygen Impacts (V 2023-01)

0.2 g to 0.5 g of the paste-like, of the divided solid, or with ceramic fibres mixed liquid material is placed into a steel tube with a volume of 15 cm^3. The heatable steel tube is connected to a high-pressure oxygen accumulator using a 750 mm long pipe (internal diameter 14 mm) and a quick opening valve.

After heating the tube to the test temperature of 60 °C minimum, the quick opening valve is opened. Preheated oxygen of 60 °C at final pressure p_F flows abruptly into the pipe and tube. In this case, the oxygen in the tube and in the pipe is heated and almost adiabatically compressed from initial pressure p_I to final pressure p_F in 17.5 ms ±2.5 ms (according to DIN EN 1797 and ISO 21010). If there is a reaction of the sample with oxygen, further tests are performed at a lower final pressure p_F. If there is no reaction of the sample with oxygen, further tests are performed at a higher final pressure p_F. The test is finished, if there is no reaction of the material detected in two test series each consisting of five single tests.

For this test, the maximum test pressure is 450 bars, and the maximum test temperature is 300 °C.