BAM
Bundesanstalt für Materialforschung und -prüfung

TEST REPORT

on Testing a Nonmetallic Material for Reactivity with Oxygen

BAM reference	22002847-E
Copy	1st copy of 2
Customer	Gemü Gebr. Müller GmbH & Co. KG Fritz-Müller-Straße 6 – 8 74653 Ingelfingen-Criesbach Germany
Date of Request	January 26, 2022
Your Reference	Herbert Biegel
Receipt of Signed Contract	February 7, 2022
Test Samples	PTFE-based sealing material Dyneon TFM 1635, batch 567 Code 5
Receipt of Samples	February 14, 2022
Test Date	February 14 to April 7, 2022
Test Location	BAM – Division 2.3 „Pressure Equipment, Accessories, Gas Detectors“; building no. 41
Test Procedure or Requirement according to	DIN EN 1797 und ISO 21010 “Cryogenic Vessels - Gas/Material Compatibility“
(in the current version)	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 annex 1.
All pressures of this report are excess pressures.

1 Documents and Test Samples

The following documents and samples were submitted to BAM:

1 Test application
Safety-related investigation on the PTFE-based sealing material Dyneon TFM 1635, batch 567 Code 5, for use in gaseous oxygen service at temperatures up to 60 °C

1 Safety Data Sheet 3M Dyneon TFM Modified PTFE Granules TFM 1635
(12 pages, 3M, Version No. 12.3, Document group: 08-8103-7,
date of issue: 25/02/2021)

1 Product Data Sheet 3M Dyneon TFM Modified PTFE Granules TFM 1635
(3 pages, 3M, Status: Jul. 2013)

1 Product drawing (1 page, Gemü, March 4, 2021)

1 Completely filled Costumer Master Data Sheet (CMDS) (January 26, 2022)

3 Molded parts of PTFE-based sealing material Dyneon TFM 1635,
batch 567 Code 5,
Color: White

2 Applied Test Methods

The PTFE-based sealing material Dyneon TFM 1635, batch 567 Code 5, 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 PTFE-based sealing material Dyneon TFM 1635, batch 567 Code 5, was provided by the customer.

3.1 Preparation of Samples

For testing, drilling chips of the PTFE-based sealing material Dyneon TFM 1635, batch 567 Code 5, were produced with a twist drill ø 4.5 mm and were used in this form.

4 Tests

4.1 Testing for Ignition Sensitivity to Gaseous Oxygen Impacts

The test method is described in annex 1. Based on the specified use conditions 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	20	no*
60	30	no*
60	40	no*
60	50	no*
60	60	on 1st impact
60	50	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 sample with oxygen could be observed at following conditions:

Sample Temperature t_i [°C]	Final Oxygen Pressure p_F [bar]
60	50

5 Summary of the Test Results

In two separate tests, each consisting of a series of five consecutive impacts, no reaction of the sample with oxygen could be observed at final pressures of 50 bars and 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 extended uncertainty is 1.7 K (according to the calibration protocol from January 10, 2022) for the temperature measuring system, and the uncertainty is 0.16 bars (according to the calibration protocol from February 4, 2022) 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 PTFE-based sealing material Dyneon TFM 1635, batch 567 Code 5, 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 PTFE-based sealing material Dyneon TFM 1635, batch 567 Code 5, for gaseous oxygen service at following use conditions:

Maximum Temperature [°C]	Maximum Oxygen Pressure [bar]
60	50

9 Comments

This safety-related investigation considers the fact, that rapid oxygen pressure changes - so-called oxygen pressure surges – cannot be safely excluded in usage.

Our opinion and interpretation are based exclusively on the results of the tested sample of a particular batch.

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.

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.

Bundesanstalt für Materialforschung und -prüfung (BAM)
12200 Berlin

April 29, 2022

Division 2.3 "Pressure Equipment, Accessories, Gas Detectors"

by order

Dr. Thomas Kasch

This document was created electronically and is valid without a signature.

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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^3 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_I, the quick opening valve is opened and preheated oxygen of 60 °C and of pressure p_F 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_I to p_F in 17.5 ms ±2.5 ms (according to DIN EN 1797 and ISO 21010) 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_F/p_I. 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_F/p_I, 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.