Test Report

Tests of different types

of flexible connector systems under real conditions

for Filcoflex B.V.

Kaatsheuvel, Netherlands

Project-No.

TL/5808/10

EX/5303/10

Möhnesee, 26 October 2010

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1 Introduction

Filcoflex B.V. manufactures flexible connector systems for the food industry. These flexible connectors could be easily installed in a so-called "Jacobs-pipework-system"[1]. Such systems are also often used in explosion endangered plant areas or units.

Such facilities are often explosion protected by means of explosion venting. In these cases the pressure resistance of the plant or the unit depends on the reduced explosion pressure occurring after venting. In most cases this reduced explosion pressure is in the range of 0.5 to 1.5 bar_g. As a result of this all parts of the plant have to withstand this explosion pressure also the flexible connector systems. That means that these flexible systems[2] have to suffer the stress caused by the pressure wave and the high temperature of the flame.

Inburex Consulting GmbH has been asked to establish an appropriate test procedure to test different flexible connector systems of equal diameter and length under realistic explosion conditions. Mr. Werner van Loon and Walter van Loon were present during the tests. They made photos and videos to document the tests.

2 Testing procedure

The explosion tests were carried out in a 1-m³ vessel. The test procedure of the experiments was performed in accordance to ISO 6184/1, DIN EN 14034/1 and 2. Detailed information concerning the test procedure are listed in the appendix. The next pictures show the technical scheme and the practical application of the explosion test rig.

[1] Fr. Jacob Söhne GmbH & Co. // Niederfeldweg 14 // D-32457 Porta Westfalica // Germany
[2] Some of these flexible systems were statically tested by water pressure tests up to a pressure of 1 barg.

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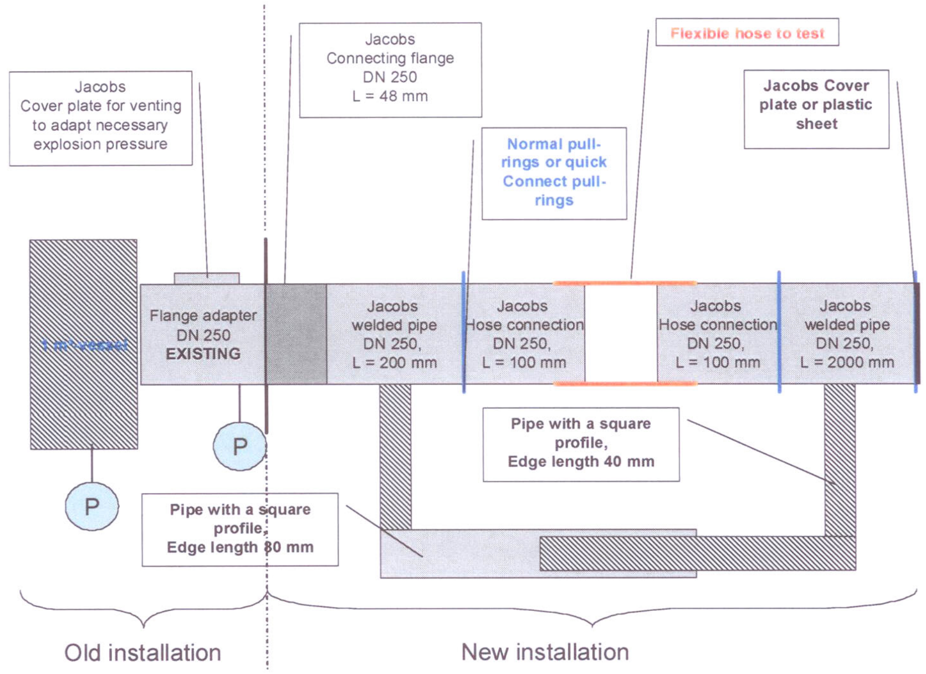


figure 1: technical scheme of the test rig

figure 2: practical application of the test rig

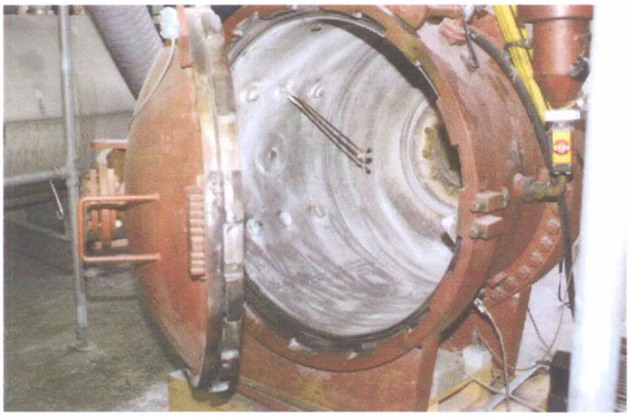
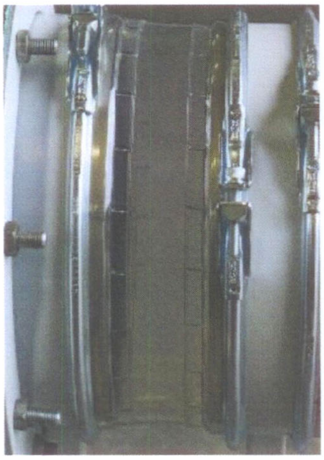


figure 3: front view of 1 m³-vessel and venting area (area of the plastic foil in the tube)

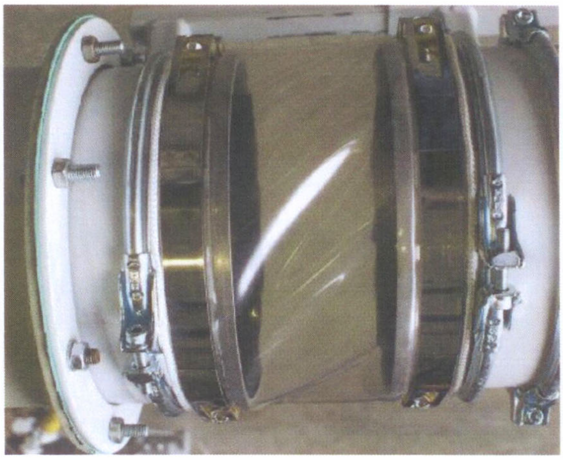
It was very difficult to ensure a reduced explosion pressure of 2 bar_g. Therefore preliminary tests were done to adjust the test parameters.

The Jacobs pipe system was closed by a venting foil with a layer thickness of 0.05 mm. In most of the tests the foil was used double-folded. Detailed information of the test conditions are listed in the appendix.

The following pictures represent the different flexible connector systems which were tested.



FSC-connector-system



KLB- connector-system

FDM- connector-system

figure 4: flexible connector systems

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3 Test Results

The single test results of the tested connector systems including the preliminary tests are listed in the appendix. Appropriate photos and videos were made by the customer and archived. A digital copy of these files is archived at Inburex Consulting GmbH to ensure the obligation to produce supporting documents.

The following picture shows a typical real explosion which was used as practical test application.

figure 5: Jacobs pipe and flexible connector system during the explosion

The pressure courses during the explosion inside the 1 m^3-vessel and in front of the flexible connector system were measured by pressure sensors.

The next picture gives an overview[3] of the explosion pressure ranges of the different flexible connector systems which were reached at the different pressure sensor locations.

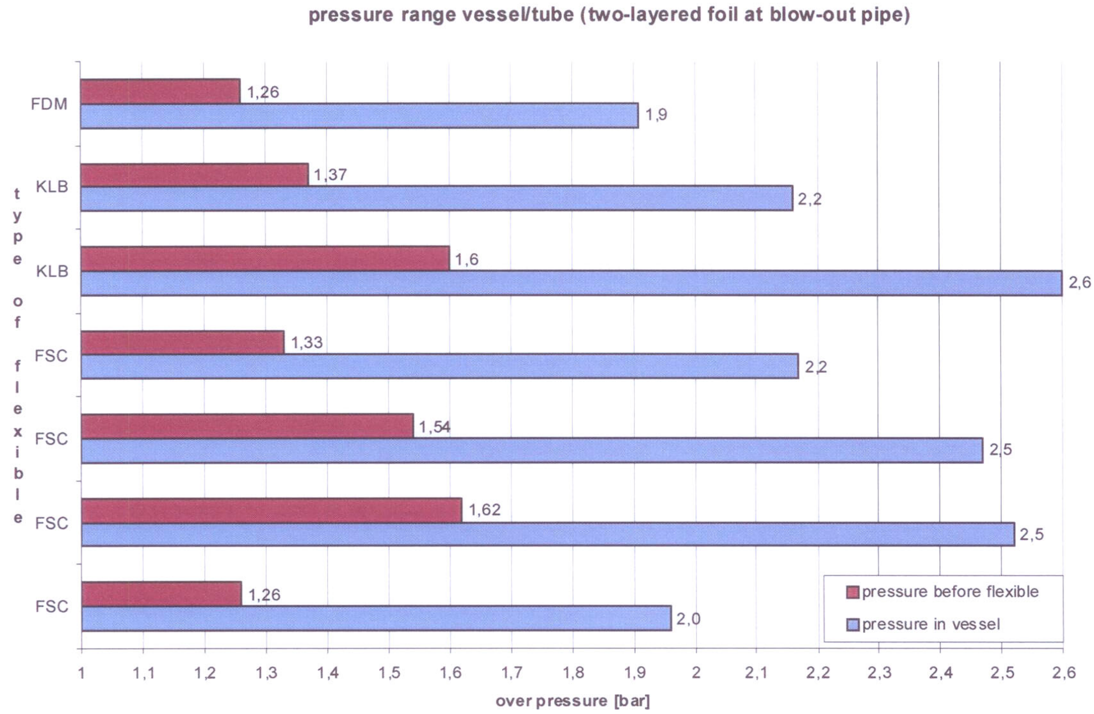

figure 6: maximum explosion pressure ranges of the different test series

It can be seen that the explosion overpressure inside the 1-m³ vessel is in the range of 2 till 2.5 bar_g.

The following diagrams (figure 7) show typical explosion pressure courses[4] during the tests of the different flexible connector systems.

[3] Due to the fact that at some tests the data acquisition respectively the video acquisition failed, here only those tests were used where in common pressure courses as well as videos were available.
4 The KSt-Value the test with flexibles installed are between 42 and 50 bar·m·s-1

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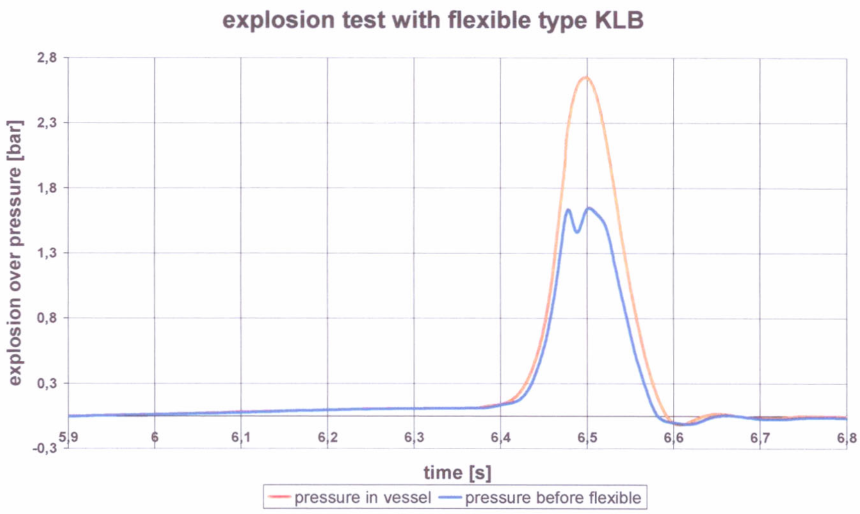

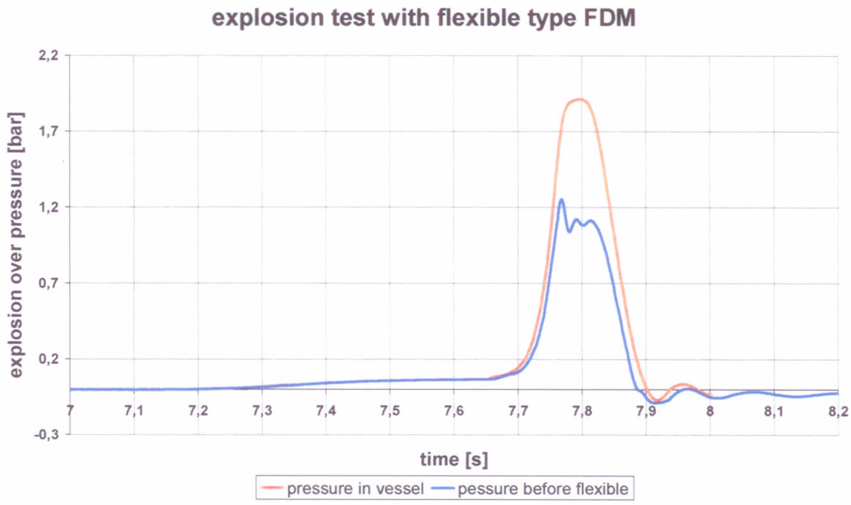

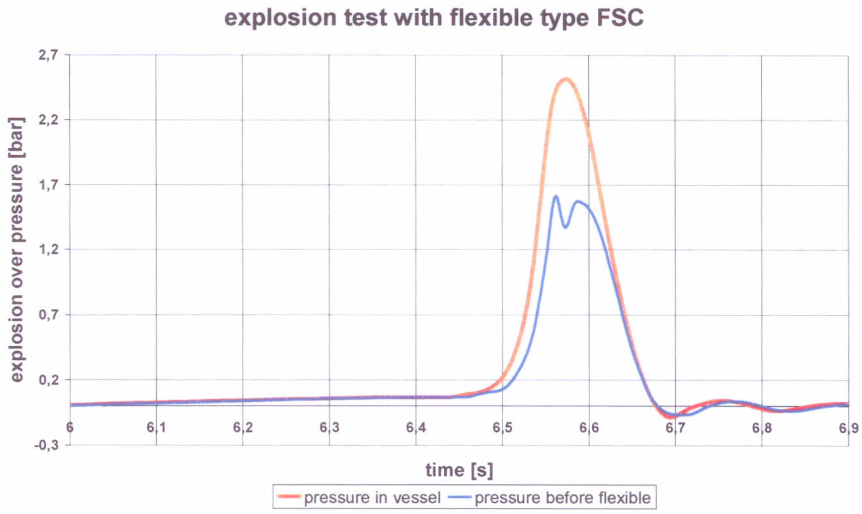

figure 7 typical pressure signal of both sensors

Summarized it can be pointed out that:

⇨ The duration of the explosion, i.e. the increase of the explosion pressure from the moment of the beginning of the explosion up to the maximum value and the following decrease to atmospheric conditions, averages 200 ms.

⇨ An averaged explosion overpressure of 1.3 bar_g stresses the connectors systems for about 50 ms. Also the flexibles are stressed thermically by the high flame temperature

The following pictures show the different tested connector systems before and after the explosion test.

Picture Before Explosion



FSC-connector-system **KLB- FSC-connector-system** **FDM- FSC-connector-system**

Typical Picture after Explosion



FSC-connector-system **KLB- FSC-connector-system** **FDM- FSC-connector-system**

figure 8: comparison of the connectors types before and after the explosion

It can be seen that on the one hand the thermal stress change partially the colour of the flexibles but on the other hand apparently the pressure stress didn't cause a break of the flexibles.

4 Summary

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Möhnesee, 26 October 2010

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5 Appendix

In the following there are detailed information of the test procedure

a. Product characteristics of the used material corn starch

1 nature of the sample: white and solid powder

2 median value: 25 µm, moisture content: 9.1 wt.-%

3 type of explosive atmosphere: dust-air mixture with the following safety properties

safety properties of cornstarch[5] (sample no. 191)

mass fraction <71 µm	100	[wt.-%]
mass fraction <32 µm	80	[wt.-%]
mass fraction <20 µm	43	[wt.-%]
median value d_{50}	22	[µm]
lower explosion limit	60	[g/m3]
Maximum Explosion Pressure	10,6	[bar]
K_{St}-constant	143	[m*bar/s]
Dust Explosion Class	St 1	-
Auto Ignition temperature (GG-oven)	440	[°C]
Minimum ignition temperature of a dust layer	420	[°C]
Burning index	3	BI

b. Characteristics of the test rig

1 dimensional sketch of the test rig

2 dust-dispersion system: baffle plate

3 dust concentration during the tests: 500 g/m³

4 explosion pressure during the tests 1.5 – 2.8 bar_g

5 Ignition energy: 2 x 5 kJ Pyrotechnical ignitors[6]

6 Ignition delay time: 0,6 s

[5] Source: GESTIS-STAUB-EX-Datenbank, sample no. 191 [http://bgia-online.hvbg.de/STAUBEX/explosuche.aspx]
[6] supplier of the ignitors: Fr. Sobbe GmbH, Fabrik elektrischer Zünder, Beylingstr 59., G-44329 Dortmund

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c. Characteristics of the explosion isolation system

1 type of explosion sensor: Pressure detection: 2 x piezoelectric transducers type 701A with charge meter type 5015A[7]

2 location of the pressure transducers: middle of the explosion chamber and in front of the flexible connector system (see figure 1 and figure 2)

d. Results of the experiments

In the following there are the single test results are listed in two tables because of two data acquisition files.

Data series	Internal Number of test sequences. After no. 9 the flexible connectors tests did start.
Weight	Dust concentration during the tests
Sensor	Kanal 1 represents the pressure sensor in the 1m³-vessel Kanal 2 represents the pressure sensor in front of the flexible connector system.
Pressure	The measured explosion overpressure (bar_g) at the different sensors positions. n.d. -> data transmission between pressure sensor and pc failed

The following table represent the test results of the **first data file** in its original version.

data serie	weight	sensor	test note	pressure
0	250	Kanal 1	Drucktest I	0,58
1	250	Kanal 2	Drucktest I	0,52
2	250	Kanal 1	Drucktest III Folie 4fach	0,45
3	250	Kanal 2	Drucktest III Folie 4fach	0,14
4	500	Kanal 1	Drucktest IV Schweissfolie 1 fach	1,58
5	500	Kanal 2	Drucktest IV Schweissfolie 1 fach	0,84
6	500	Kanal 1	Drucktest mit kompensator Schweissfolie 1 fach	1,72
7	500	Kanal 2	Drucktest mit kompensator Schweissfolie 1 fach	0,88
8	500	Kanal 1	Drucktest mit Entlastung und Rohrverlängerung	1,94
9	500	Kanal 2	Drucktest mit Entlastung und Rohrverlängerung	1,11
10	500	Kanal 1	Montag-Test doppel folie	1,91
11	500	Kanal 2	Montag-Test doppel folie	1,26
12	500	Kanal 1	Test 2_Montag_doppel_folie	0,06
13	500	Kanal 2	Test 2_Montag_doppel_folie	1,42
14	500	Kanal 2	Test 3_Montag_doppel_folie	1,47

[7] Kistler Instrumente GmbH, Daimlerstrasse 6, G-73760 Ostfildern

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The following table represents the test results of the **second data file** in its original version.

No. Test	weight	sensor	test note	pressure
0	500	Kanal 1	Versuch4_montag_doppel_folie	n.d
1	500	Kanal 2	Versuch4_montag_doppel_folie	1,45
2	500	Kanal 1	Versuch5-2x folie_ FSC	n.d
3	500	Kanal 1	Versuch7_FSC_doppel folie	2,52
4	500	Kanal 2	Versuch7_FSC_doppel folie	1,62
5	500	Kanal 2	Versuch8_FSC_doppel folie	1,54
6	500	Kanal 1	Versuch8_FSC_doppel folie	2,47
7	500	Kanal 1	Versuch9_FSC_doppel folie	2,17
8	500	Kanal 2	Versuch9_FSC_doppel folie	1,33
9	500	Kanal 1	Versuch10_klb_doppel folie	2,6
10	500	Kanal 2	Versuch10_klb_doppel folie	1,6
11	500	Kanal 1	versuch11_KLB_2xfolie	2,49
12	500	Kanal 1	Versuch12_KLB_2xfolie	2,16
13	500	Kanal 2	Versuch12_KLB_2xfolie	1,37
14	500	Kanal 1	Versuch12_FSC_4xfolie_2xAluinlay	2,79
15	500	Kanal 2	Versuch12_FSC_4xfolie_2xAluinlay	2,14
16	500	Kanal 1	versuch14_fdm_4xfolie_2xaluinlay	2,81
17	500	Kanal 2	versuch14_fdm_4xfolie_2xaluinlay	1,89