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AN INVESTIGATION INTO THE PRESSURE GENERATING CHARACTERISTICS OF EXFOGUARD 'GRAFATE' INTUMESCENT MATERIAL

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Prepared for:

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AN INVESTIGATION INTO THE PRESSURE GENERATING CHARACTERISTICS OF EXFOGUARD 'GRAFATE' INTUMESCENT MATERIAL

SUMMARY

Comparative tests have been performed upon samples of 'Exfoguard Grafate' intumescent and 'Palusol' type intumescent, in order to obtain an indication of their pressure generating performance.

Two sets of tests were performed; one set pre-heating the seal slowly to 165 - 185°C, then heating with a blowtorch to obtain maximum pressure (Tests 1 & 2) the other set with no pre-heating (blowtorch, only Tests 3 & 4). The results were as follows:-

Test 1 : Exfoguard Grafate

Peak force	.....	42.17 kgf
Peak pressure	.....	1.78 kg/cm² (1.75 Bar)
Peak pressure/unit length	.....	354.37 kgf/m

Test 2 : 'Palusol' type

Peak force	.....	26.69 kgf
Peak pressure	.....	1.79 kg/cm² (1.75 Bar)
Peak force/unit length	.....	224.29 kgf/m

Test 3 : Exfoguard Grafate

Peak force	.....	70.15 kgf
Peak pressure	.....	2.15 kg/cm² (2.1 Bar)
Peak force/unit length	.....	588.5 kgf/m

Test 4 : 'Palusol' type

Peak force	.....	42.93 kgf
Peak pressure	.....	2.56 kg/cm² (2.51 Bar)
Peak force/unit length	.....	360 kgf/m

1. INTRODUCTION

On the instructions of the Sponsor, whose letter of 29 October 1992 refers, a series of comparative tests have been performed upon ' Exfoguard Grafate' and 'Palusol' type intumescent materials. The tests were performed on Thursday 24 November 1992. The samples were received on the day of the test.

2. DESCRIPTION OF TEST MATERIAL

The test specimens were strips of 'Exfoguard Grafate', 8mm wide by 2mm deep, and strips of 'Palusol' type intumescent (manufactured by BASF) of the same dimensions.

Exfoguard Grafate was described by the Sponsor as "Inter-collated graphite in a monomer carrier".

3. TEST METHOD

The strips of seal material were held within a groove in the test apparatus and were heated so that expansion took place. An 'anvil' was positioned over the seal, which was attached to a load cell. The expanding intumescent exerted a force on the load cell, which was measured and recorded.

The test apparatus comprised a body which supported and restrained the seal, comprising 2 No. steel plates 300mm long by 70mm wide by 12mm thick bolted to a 2mm thick steel plate, long edges 70mm apart. The assembly was held together with M6 bolts through 25mm steel angles. 2mm thick pieces of non-combustible millboard were glued to the steel plate with a 10mm wide gap full length. The resulting groove (10mm by 2mm) was intended to simulate the restraint conditions encountered by a seal within a doorset.

An 'anvil' of a non-combustible 'Supalux' board was attached, via a steel backing plate, to a 100 kgf load cell. The load cell and anvil were attached to an adjustable frame rigidly mounted on the body of the apparatus. The anvil was thus positioned directly over the centre of the intumescent material.

The anvil dimensions were 119mm long by 50mm wide, and it was adjusted so that it was 2mm above the seal surface.

The seal material was installed within the groove, with a Type 'K' thermocouple under the seal next to the 2mm steel plate. Heat was applied to the steel via the 70mm wide gap between the 12mm thick plates (which were insulated with ceramic fibre blanket). 2 experiments were performed on each seal material. In tests 1 and 2 the apparatus was placed in front of a pre-heated electrical furnace, and the face of the seal next to the 2mm steel plate was slowly heated to approximately 180°C.

The apparatus was then removed from the furnace and a Butane blow torch was applied to the steel plate, heating the seal up quickly to around 650°C. The maximum load cell output was noted in each case.

Tests 3 and 4 were identical to 1 and 2, with the exception that furnace pre-heating of the apparatus was not applied. Some additional information was gained in test 3; the variation in load cell output with respect to time was noted, and is presented graphically in Figure 2.

A diagram of the test apparatus can be seen in Figure 1.

The peak force exerted on the anvil, the peak pressure on the area of contact of the seal (measured after removal of the anvil post-test), and the peak force per unit of seal length were calculated in each case.

4. CALCULATION

4.1 To obtain force:-

Load cell calibration is 3.0047 mV/V full scale (100kg). The applied voltage was 10V.

$$\therefore \text{load cell output (V)} = 30.0047 \text{ mV}/100\text{kg} = 0.3 \text{ mV/kg} = 3.33 \text{ kg/mV}$$

$\therefore 3.33V$ = force on load cell (kgf)

4.2 To obtain pressure:-

$$\text{Pressure (P)} = \frac{\text{Force}}{\text{Area}}$$

$$\therefore P = \frac{3.33V}{\text{Area}} \quad (kg/cm^2)$$

(N.B. $kg/cm^2 \approx$ Bar)

4.3 To obtain force per unit seal length:-

Force per unit length $(\underline{F}) = \frac{3.33V}{L} \quad \frac{}{0.119}$ kgf/m

5. RESULTS AND DISCUSSION

Test 1 : Exfoguard Grafate

Peak Voltage = 12.67mV at 515°C
∴ Peak force = 42.2kgf

Area of contact with anvil = 23.7 cm²
∴ Peak pressure = 1.78kg/cm² (1.75 Bar)

Peak Force per unit seal length = 354.37 kgf/m

Test 2: Palusol

Peak Voltage = 8.02mV at 453°C
∴ Peak force = 26.69 kgf

Area of contact with anvil = 14.9 cm²
∴ Peak pressure = 1.79 kg/cm² (1.75 Bar)

Peak Force per unit length of seal = 224.29 kgf/m

Test 3 : Exfoguard Grafate

Peak Voltage = 21.07 mV at 540°C
∴ Peak force = 70.15 kgf

Area of contact with anvil = 32.7 cm²
∴ Peak pressure = 2.15 kg/cm² (2.1 Bar)

Peak force per unit seal length = 588.5 kgf/m

N.B. See also Fig. 2. for a pressure/temperature curve.

Test 4 : Palusol

Peak Voltage = 12.9 mV at 687°C
Peak force = 42.93 kgf

Area of contact with anvil = 16.75 cm^2
∴ Peak pressure = 2.56 kg/cm^2 (2.51 Bar)

Peak force per unit seal length = 360 kgf/m

It can be seen from the above that the pressure generated by the two seal materials under similar conditions are approximately equivalent. This is, however, influenced by the lack of lateral spread of the Palusol intumescent, as evidenced by the smaller contact areas. It is therefore considered that it may be more appropriate to compare force per unit length of seal; this gives a direct comparison of the amount of force that the seal would exert on its substrate (under test conditions).

It can be seen from the above data that, under the conditions of this test, the 'Exfoguard Grafate' intumescent material exerted 1.6 times more force per unit length of seal than the 'Palusol' type intumescent.

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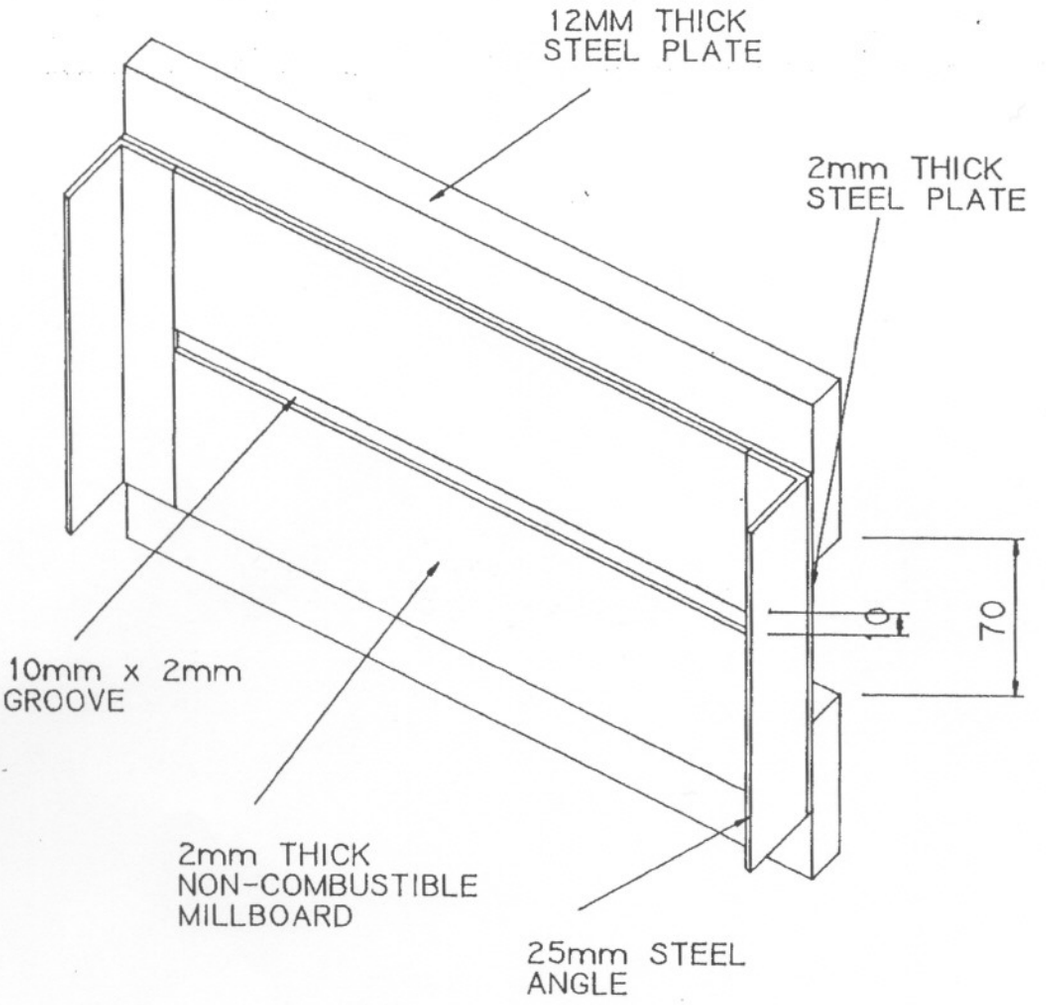
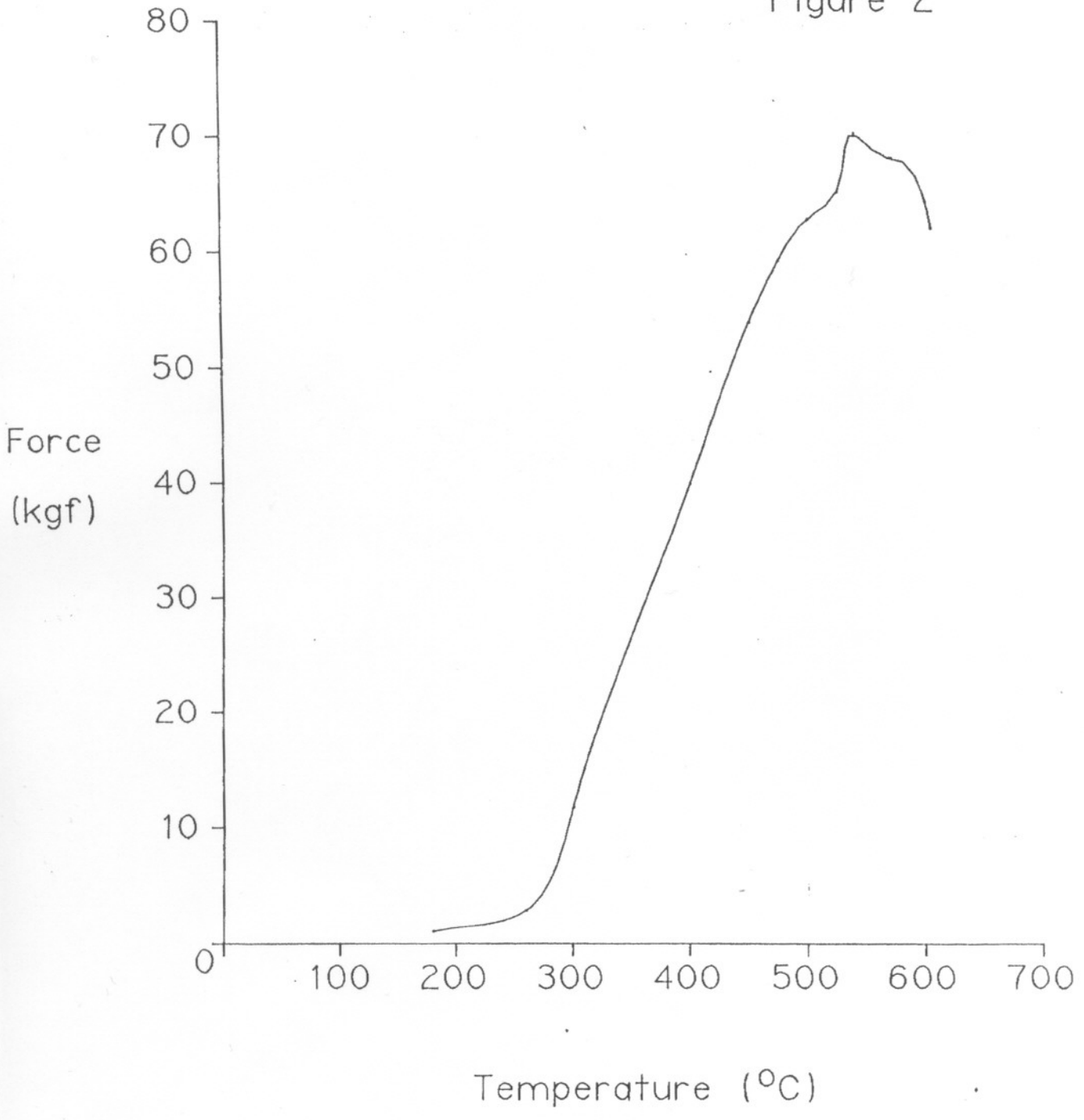


Figure 1.

Diagram of test apparatus

Load cell is attached to the 25mm steel angle at both ends.

Figure 2


80
70
60
50
40
30
20
10
0
Force
(kgf)
100
200
300
400
500
600
700
Temperature (°C)