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OUTGASSING TEST OF UMBRA
CUSCINETTI BEARING CAGES

Code:

VIR-TRE-PIS-3400-130


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Date: 20/04/1998

	<p>Umbra Cuscinetti cages</p>	<p>Doc: VIR-TRE-PIS-3400-130 code Issue: 1 Date: 20/04/1998 Page: 2</p>
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CHANGE RECORD

<i>Issue/Rev</i>	<i>Date</i>	<i>Section affected</i>	<i>Reason/ remarks</i>

Authors:	Date	Signature
<p>M. Bernardini H. B. Pan R. Poggiani</p>		
<p>Approved by:</p>		



 The logo consists of a stylized 'V' shape formed by three curved lines, with the word 'VIRGO' written in a bold, sans-serif font below it.	Umbra Cuscinetti cages	Doc: VIR-TRE-PIS-3400-130 code Issue: 1 Date: 20/04/1998 Page: 3
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In this note we briefly report the outgassing measurements performed on the cages of the bearings from Umbra Cuscinetti. The measurement method is described in detail in VACPISA 025.

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1 - System performances

We performed a baking of the test chamber at 250 °C for several days achieving a final base pressure of $\sim 10^{-10}$ mbar.

The main components of outgassing after baking were H₂, H₂O, N₂/CO, CO₂. The internal surface of the chamber is 3200 cm².

2 - Measurement of the outgassing rate of bearings

The experimental samples were three cages for bearings manufactured by Umbra Cuscinetti, Italy. The nominal material was polyimide. The cages have been cleaned with an ultrasound bath of isopropyl alcohol for 40 minutes and a few hours baking in air at 100 °C.

We monitored the evolution of outgassing (time is measured from beginning of the test through the whole paper):

t(h)	T(°C)	p ₁ (mbar)	p ₂ (mbar)	Q(mbar l/s)
1.0	25	1.7×10^{-5}	2.0×10^{-6}	3.0×10^{-4}
18.5	25	3.3×10^{-6}	4.3×10^{-7}	5.7×10^{-5}
23	25	2.8×10^{-6}	3.6×10^{-7}	4.9×10^{-5}
40.5	25	1.7×10^{-6}	2.2×10^{-7}	3.0×10^{-5}
112.5	25	7.0×10^{-7}	9.0×10^{-8}	1.0×10^{-5}
143	25	5.7×10^{-7}	7.3×10^{-8}	9.9×10^{-6}
162	25	3.3×10^{-7}	4.0×10^{-8}	5.8×10^{-6}

The mass spectrum after 162 hours is shown in Fig. 1.

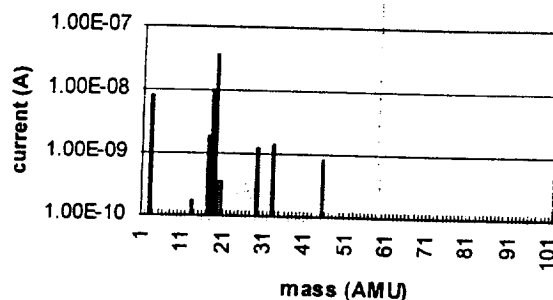


Fig. 1 Outgassing spectrum after 162 hours pumping at room temperature

We set temperature at 50 °C for 167 hours and monitored the evolution of outgassing:

t(h)	T(°C)	p1(mbar)	p2(mbar)	Q(mbar l/s)
163	53	2.3x10 ⁻⁶	3.0x10 ⁻⁷	4.0x10 ⁻⁵
163.5	52	5.1x10 ⁻⁶	7.0x10 ⁻⁷	8.8x10 ⁻⁵
168	54	3.7x10 ⁻⁶	5.2x10 ⁻⁷	6.4x10 ⁻⁵
185	52	1.7x10 ⁻⁶	1.9x10 ⁻⁷	3.0x10 ⁻⁵
193	49	1.2x10 ⁻⁶	1.6x10 ⁻⁷	2.1x10 ⁻⁵
212	50	7.9x10 ⁻⁷	1.0x10 ⁻⁷	1.4x10 ⁻⁵
218	49	6.7x10 ⁻⁷	8.6x10 ⁻⁸	1.2x10 ⁻⁵
304.5	48	1.8x10 ⁻⁷	1.9x10 ⁻⁸	3.2x10 ⁻⁶
307	48	1.5x10 ⁻⁷	1.6x10 ⁻⁸	2.7x10 ⁻⁶
330	47	2.6x10 ⁻⁷	2.7x10 ⁻⁸	4.7x10 ⁻⁶

The mass spectrum at 330 hours is shown in Fig. 2.

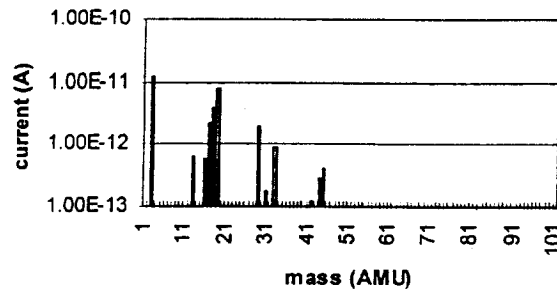


Fig. 2 Outgassing spectrum after 167 hours at 50 °C

We set temperature at 100 °C for 222 hours and monitored the evolution of outgassing:

t(h)	T(°C)	p1(mbar)	p2(mbar)	Q(mbar l/s)
330.25	77	5.0x10 ⁻⁷	5.6x10 ⁻⁸	8.9x10 ⁻⁶
330.5	110	6.8x10 ⁻⁶	7.5x10 ⁻⁷	1.2x10 ⁻⁴
330.75	96	2.2x10 ⁻⁶	2.8x10 ⁻⁷	3.8x10 ⁻⁵
331	96	1.8x10 ⁻⁶	2.4x10 ⁻⁷	3.1x10 ⁻⁵
337	100	1.2x10 ⁻⁶	1.4x10 ⁻⁷	2.1x10 ⁻⁵
355	100	1.5x10 ⁻⁶	1.9x10 ⁻⁷	2.6x10 ⁻⁵
361	100	4.2x10 ⁻⁷	3.7x10 ⁻⁸	7.7x10 ⁻⁶
379	100	2.2x10 ⁻⁷	2.1x10 ⁻⁸	4.0x10 ⁻⁶
449	100	3.6x10 ⁻⁷	4.8x10 ⁻⁸	6.2x10 ⁻⁶
474	100	2.7x10 ⁻⁷	3.5x10 ⁻⁸	4.7x10 ⁻⁶
523	100	2.8x10 ⁻⁷	3.4x10 ⁻⁸	4.9x10 ⁻⁶
552	100	2.5x10 ⁻⁷	2.8x10 ⁻⁸	4.4x10 ⁻⁶

The mass spectrum after 31 hours at 100 °C is shown in Fig. 3.

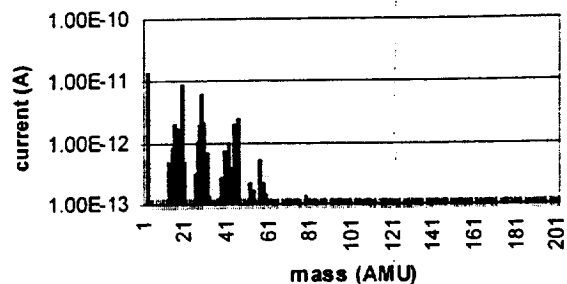


Fig. 3 Outgassing spectrum after 31 hours at 100 °C

Some organic fragments appear, particularly at masses 41, 43, 45, 53, 55, 57. The fragments are still present after 144 hours at 100 °C, and some higher mass fragments have appeared.

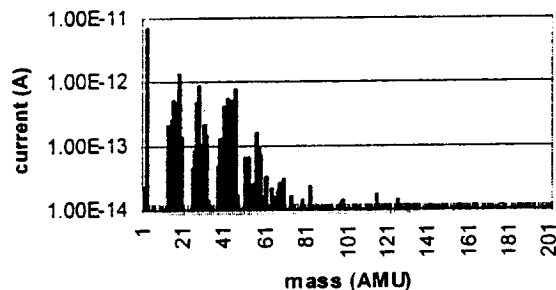


Fig. 4 Outgassing spectrum after 144 hours at 100 °C

We set temperature at 150 °C for 113 hours and monitored the evolution of outgassing:

t(h)	T(°C)	p ₁ (mbar)	p ₂ (mbar)	Q(mbar l/s)
552	120	4.6x10 ⁻⁷	5.2x10 ⁻⁸	8.2x10 ⁻⁶
552.25	154	2.3x10 ⁻⁵	2.0x10 ⁻⁶	4.2x10 ⁻⁴
552.5	150	1.0x10 ⁻⁵	8.5x10 ⁻⁷	1.8x10 ⁻⁴
552.75	150	8.8x10 ⁻⁶	6.8x10 ⁻⁷	1.6x10 ⁻⁴
553	150	8.4x10 ⁻⁶	6.7x10 ⁻⁷	1.6x10 ⁻⁴
553.5	150	7.6x10 ⁻⁶	6.1x10 ⁻⁷	1.4x10 ⁻⁴

617	150	1.3×10^{-6}	5.5×10^{-7}	1.5×10^{-5}
665	150	1.7×10^{-6}	1.2×10^{-7}	3.2×10^{-5}

The mass spectrum measured after 2 hours at 150 °C is shown in Fig. 5.

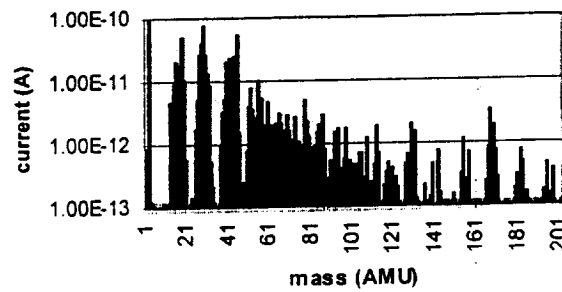


Fig. 5 Outgassing spectrum after 2 hours at 150 °C

We note the presence of clusters centred at multiples of mass 14, typical of organic contamination. There are still some fragments after 113 hours at 150 °C as shown in Fig. 6.

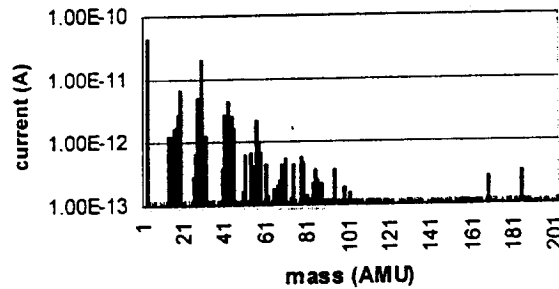


Fig. 6 Outgassing spectrum after 113 hours at 150 °C

We switched off the heating and we measured:

t(h)	T(°C)	p ₁ (mbar)	p ₂ (mbar)	Q(mbar l/s)
742	15	2.3×10^{-7}	5.0×10^{-8}	3.6×10^{-6}

785	15	9.3×10^{-8}	6.2×10^{-9}	1.7×10^{-6}
787	15	3.9×10^{-8}	5.0×10^{-9}	6.8×10^{-7}

The mass spectrum at 787 hours is shown in Fig. 7.

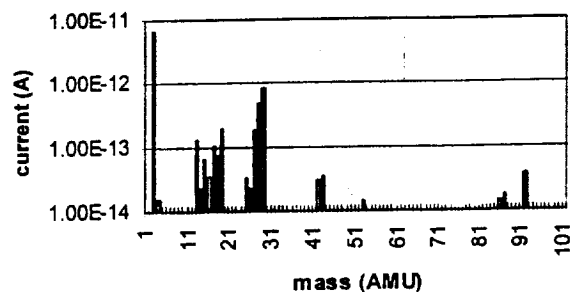


Fig. 7 Outgassing spectrum after the first thermal cycle

Since some organic contamination was present during the various steps in temperature, we checked if it had been removed by the thermal cycle. We heated the samples at 80 °C for 169 hours:

t(h)	T(°C)	p ₁ (mbar)	p ₂ (mbar)	Q(mbar l/s)
787.25	51	4.9×10^{-8}	1.5×10^{-8}	6.8×10^{-7}
787.5	90	9.9×10^{-8}	3.1×10^{-9}	1.8×10^{-6}
787.75	76	1.4×10^{-7}	8.4×10^{-9}	2.6×10^{-6}
788	84	2.1×10^{-7}	1.1×10^{-8}	4.0×10^{-6}
788.5	78	4.7×10^{-7}	1.8×10^{-8}	9.0×10^{-6}
789	78	9.1×10^{-7}	2.9×10^{-8}	1.8×10^{-5}
789.5	83	1.0×10^{-6}	3.6×10^{-8}	1.9×10^{-5}
790	77	8.5×10^{-7}	3.1×10^{-8}	1.6×10^{-5}
790.5	81	6.0×10^{-7}	2.8×10^{-8}	1.1×10^{-5}
791.5	81	2.5×10^{-7}	2.0×10^{-8}	4.6×10^{-6}
793	81	1.9×10^{-7}	1.3×10^{-8}	3.5×10^{-6}
809.5	84	3.9×10^{-8}	4.1×10^{-9}	6.0×10^{-7}
811	77	9.4×10^{-8}	8.4×10^{-9}	1.7×10^{-6}
834	80	3.1×10^{-7}	3.5×10^{-8}	5.5×10^{-6}

A spectrum taken at 834 hours is shown in Fig. 8. Some fragments at 41, 43 and 55 are evident.

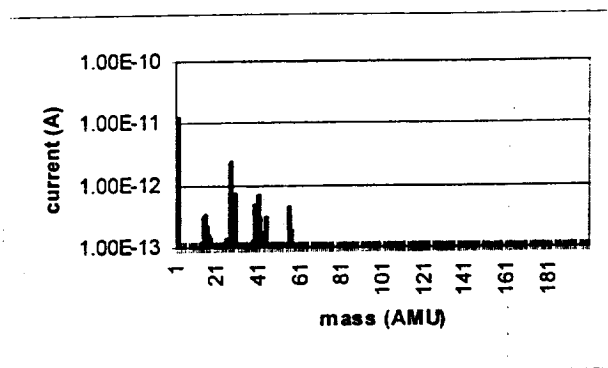


Fig. 8 Outgassing spectrum during the second heating at 80 °C

We switched off and we started heating again, first at 80 °C then at 150 °C:

t(h)	T(°C)	p ₁ (mbar)	p ₂ (mbar)	Q(mbar l/s)
882.5	14	2.0x10 ⁻⁸	2.6x10 ⁻⁹	3.5x10 ⁻⁷
883.5	83	3.2x10 ⁻⁸	3.2x10 ⁻⁹	5.8x10 ⁻⁷
884.5	136	1.7x10 ⁻⁷	2.7x10 ⁻⁸	2.9x10 ⁻⁶
886.5	152	5.6x10 ⁻⁷	6.0x10 ⁻⁸	1.0x10 ⁻⁵
1002.5	152	5.8x10 ⁻⁶	2.0x10 ⁻⁷	1.1x10 ⁻⁴
1050.5	152	2.7x10 ⁻⁶	2.3x10 ⁻⁷	4.9x10 ⁻⁵
1144.5	152	2.2x10 ⁻⁷	2.0x10 ⁻⁸	4.0x10 ⁻⁶

The spectrum taken at 1050.5 hours is shown in Fig. 9. Some organic fragments have appeared again.

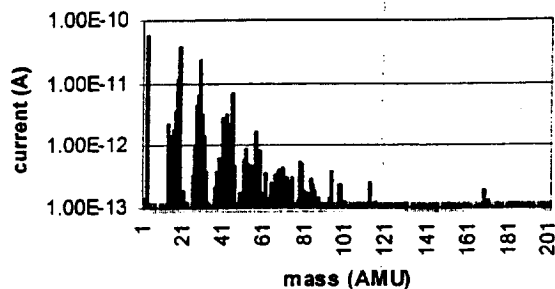


Fig. 9 Outgassing spectrum during the third heating

We switched off heating and we measured:

t(h)	T(°C)	p ₁ (mbar)	p ₂ (mbar)	Q(mbar l/s)
1147	132	1.3x10 ⁻⁷	1.1x10 ⁻⁸	2.4x10 ⁻⁶
1175	15	1.2x10 ⁻⁸	1.4x10 ⁻⁹	2.1x10 ⁻⁷
1176.5	15	2.8x10 ⁻⁸	2.2x10 ⁻⁹	5.2x10 ⁻⁷
1194	15	6.3x10 ⁻⁹	7.1x10 ⁻¹⁰	1.1x10 ⁻⁷
1200	20	5.9x10 ⁻⁹	6.2x10 ⁻¹⁰	1.1x10 ⁻⁷
1219	14	4.6x10 ⁻⁹	6.8x10 ⁻¹⁰	7.9x10 ⁻⁸

A spectrum taken at 1219 hours is shown in Fig. 10.

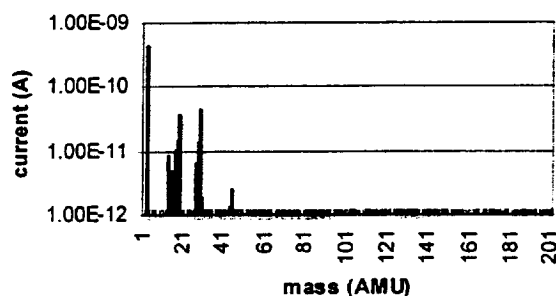


Fig. 10 Outgassing spectrum during the second cooling down

After the two thermal cycles described above we tried to ramp temperature to 80 °C again in steps of 20 °C/h:

t(h)	T(°C)	p ₁ (mbar)	p ₂ (mbar)	Q(mbar l/s)
1218.5	45	6.9x10 ⁻⁹	7.8x10 ⁻¹⁰	1.2x10 ⁻⁷
1219.5	58	1.2x10 ⁻⁸	1.3x10 ⁻⁹	2.1x10 ⁻⁷
1222	84	1.9x10 ⁻⁸	2.0x10 ⁻⁹	3.4x10 ⁻⁷
1297	83	1.7x10 ⁻⁸	1.9x10 ⁻⁹	3.0x10 ⁻⁷
1320	78	1.1x10 ⁻⁸	1.0x10 ⁻⁹	2.0x10 ⁻⁷
1338	83	1.0x10 ⁻⁸	1.6x10 ⁻⁹	1.7x10 ⁻⁷

The spectrum at 1297 hours is shown in Fig. 11. Some organic fragments do appear again.

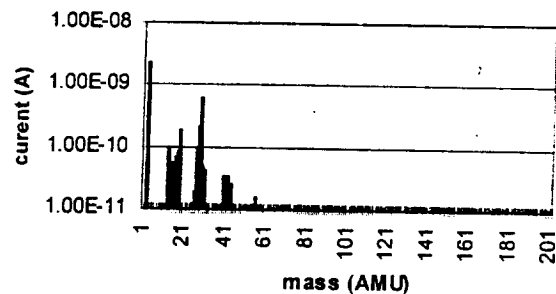


Fig. 11 Outgassing spectrum during the fourth baking

We switched off heating and we measured:

t(h)	T(°C)	p ₁ (mbar)	p ₂ (mbar)	Q(mbar l/s)
1338.5	57	3.9x10 ⁻⁹	5.4x10 ⁻¹⁰	6.7x10 ⁻⁸
1341	35	4.5x10 ⁻⁹	5.0x10 ⁻¹⁰	8.0x10 ⁻⁸
1341.5	32	5.0x10 ⁻⁹	5.4x10 ⁻¹⁰	8.9x10 ⁻⁸
1344	28	4.8x10 ⁻⁹	5.1x10 ⁻¹⁰	8.6x10 ⁻⁸
1368	15	1.4x10 ⁻⁹	2.3x10 ⁻¹⁰	2.3x10 ⁻⁸
1393	15	2.0x10 ⁻⁹	4.7x10 ⁻¹⁰	3.1x10 ⁻⁸

1357.5	15	9.8×10^{-10}	2.1×10^{-10}	1.5×10^{-8}
1482	15	7.7×10^{-10}	1.7×10^{-10}	1.2×10^{-8}
1655	15	1.9×10^{-9}	3.3×10^{-10}	3.1×10^{-8}
1681	15	1.5×10^{-9}	2.8×10^{-10}	2.4×10^{-8}
1699	15	1.2×10^{-9}	2.3×10^{-10}	1.9×10^{-8}

The spectrum measured at the end of cooling is shown in Fig. 12.

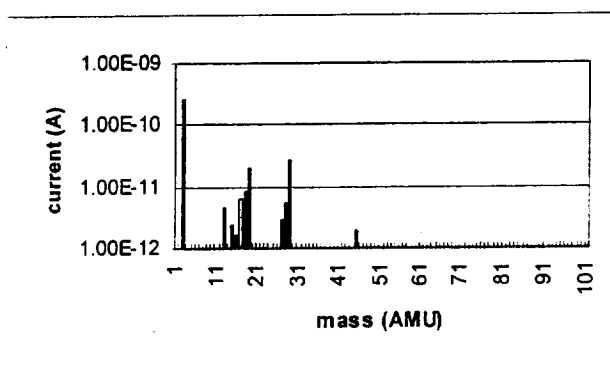


Fig. 12 Outgassing spectrum after the last cooling

The outgassing rate evolution is summarized in Fig. 13.

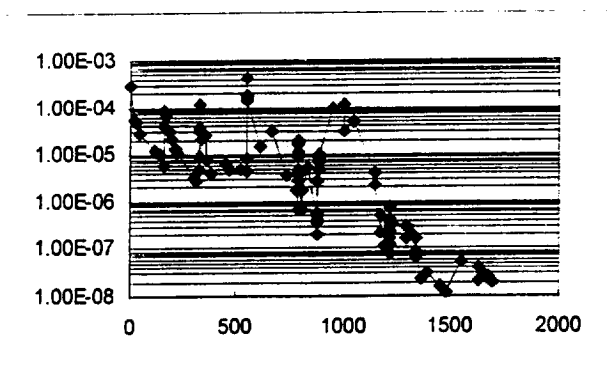



Fig. 13 Time evolution of the outgassing rate

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3 - Discussion

The outgassing flow measured for the three cages after the various thermal cycles was $\sim 10^{-8}$ mbar l s⁻¹. The various thermal cycles were not able to completely remove the organic contaminants, which appear again any time the cages are heated, even at 80 °C. Moreover, the composition of mass spectrum suggests the presence of polyamide in the cage composition. At a visual inspection, we observed that the color of the cages was slightly changed at the end of the test. During the test we had to degas gauges several times because of contamination. After the test the chamber was very contaminated. An orange contaminant layer was found on the chamber diaphragm where cages have been posed during the test. In a further investigation we discovered a similar contamination on the opposite diaphragm side (facing the pump) as well.