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Memorandum

# THE PERMEABILITY OF SOME PLASTIC MATERIALS TO H<sub>2</sub>, He, N<sub>2</sub>, O<sub>2</sub>, AND A

R. S. BARTON

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DEPARTMENT OF DEFENSE  
PLASTICS TECHNICAL EVALUATION CENTER  
PICATINNY ARSENAL, DOVER, N. J.

C. T. R. Division

Atomic Energy Research Establishment,

Harwell, Berkshire.

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THE PERMEABILITY OF SOME PLASTIC MATERIALS TO  
H<sub>2</sub>, He, N<sub>2</sub>, O<sub>2</sub> AND A.

by  
R. S. Barton

ABSTRACT

The report consists of a table showing the permeability of a number of plastics to H<sub>2</sub>, He, N<sub>2</sub>, O<sub>2</sub> and A and describes the apparatus and technique used to obtain the information.

C.T.R. Division,  
U.K.A.E.A. Research Group,  
Atomic Energy Research Establishment,  
HARWELL

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## CONTENTS

	<u>Page No</u>
1. Introduction	1
2. Apparatus	1
3. Experimental procedure	2
4. Calculation of permeability	2
References	3

## TABLE

### Table

- 1 Permeability expressed in ccs at NP x cm<sup>-2</sup> x cm<sup>1</sup> (thickness)  
x secs<sup>-1</sup> x cm<sup>-1</sup> Hg, measured at 23°C ± 1°.

## ILLUSTRATIONS

### Fig.

- 1 Apparatus.  
2 Sample support.

## 1. Introduction

The study of permeability of plastic materials was undertaken as part of a programme to determine which were most suitable for use in the construction of high vacuum systems.

Some of the synthetic rubbers and one natural rubber have already been studied and were the subject of a previous report<sup>1</sup>.

## 2. Apparatus

The apparatus used was similar to that described by G.J. van Amerongen<sup>2</sup> and R.H.V.M. Dawton<sup>3</sup>.

A circular disc, B (Fig.1) of the material under observation was sandwiched between the open ends of the two halves of the cylindrical glass vacuum chamber AC, thus separating it into two compartments A and C.

The experiment consisted of measuring the gas flow through the sample with C at atmospheric pressure and with A exhausted.

Compartment A (the low pressure chamber) was connected, as seen in Fig. 1, via an isolation valve E, to a liquid nitrogen trapped Hg diffusion pump.

Measurements of the pressure within the chamber A were made by use of a McLeod Gauge D.

The compartment C (the high pressure chamber) was similarly pumped and could be isolated from its pumping system by the valve F. In this case an Hg manometer H, was used to measure the pressure in the chamber.

The gas involved in the experiment was introduced into C through a needle valve G.

To prevent distortion of the specimen during the period when the chamber C was at atmospheric pressure and A under vacuum, a support of the type shown in Fig. 2, was used. This also served to assist in forming a good vacuum seal and in defining the area of the specimen under test.

It consisted of a brass disc of similar outside diameter to that of the open end of the glass chamber which it served to terminate. The disc was recessed to house a mat of wire gauze which was in contact on one side with the specimen and on the other with the brass disc. The recessed portion of the brass disc was perforated by a large number of holes each about 5 mms. diameter. By this method the specimen was given support at a large number of points without practically reducing the surface involved in the experiment. This was regarded as that enclosed by the knife edge which formed the boundary of the recessed region.

A vacuum seal between the brass disc and the end of the glass chamber was made either by black wax or Indium. That between the brass disc and the specimen by the knife edge alone or the knife edge backed by Indium.

Temperature measurements were made by use of a thermometer attached to the sample chamber, which was screened from draughts.

No special arrangements were made to hold the sample at constant temperature since it was found that the ambient temperature of the laboratory remained within the required limits for sufficient periods of time to enable results to be obtained.

### 3. Experimental

The apparatus with the sample in position was allowed to pump until the natural leak of the chamber A was constant. This was measured by isolating the chamber for some chosen interval of time and observing the pressure rise on the McLeod gauge D (fig. 1).

Chamber C was then isolated from its pumps and filled to a pressure of 76 cms Hg with the gas to be studied.

The chamber A was again isolated periodically for the same interval of time as before, observing the pressure rise. This procedure was repeated until the rate of pressure rise became constant, to within 5%. (The time required to reach equilibrium varied with the type of gas and material, often being 1 to 2 days).

C was then pumped again until the natural leak was constant. If this was not the same as it was at the outset of the experiment the cause was investigated, corrected and the experiment repeated.

After the procedure had been carried out for each gas involved, a second check series of observations was made. This was usually obtained on another identical apparatus.

Repeatability of results and consideration of accuracy of instrumentation indicate the results shown to be within  $\pm 10\%$ .

### 4. Calculation

The permeability of the material to the gas being studied was calculated by use of the following formula:

$$V \frac{dp}{dt} \times \frac{d \times 1.3 \times 10^{-6}}{AP}$$

where  $dp$  = change of pressure expressed in microns of Hg in a time interval  $dt$  seconds.

$V$  = Volume of the chamber and McLeod gauge expressed in ccs.

$P$  = Pressure difference across the specimen between C and A expressed in cms Hg.

$A$  = Area of sample under test expressed in  $\text{cm}^2$

$d$  = Thickness of sample expressed in cms.

$1.3 \times 10^{-6}$  = Conversion factor ccs at 1  $\mu$  to ccs at 76 cms Hg.

The results are therefore expressed as  $\text{ccs at NP} \times \text{cm}^{-2} \times \text{cm}^1$  (thickness)  $\times \text{secs}^{-1} \times \text{cm}^{-1} \text{Hg}$ .

A list of results is given in Table I.

#### References

1. The permeability of a natural rubber and some rubber-like materials to  $\text{H}_2$ , He,  $\text{N}_2$   $\text{O}_2$  and A. R.S. Barton, A.E.R.E. Report No. Z/M 210. (1958).
2. Permeability of Different Rubbers to Gas and its Relation to Diffusivity and Solubility. G.J. van Amerongen, Journal Applied Physics, Vol. 17, No. 11, November 1946.
3. High Vacuum Shaft Seals, Flanged Joints and the Gassing and Permeability of Rubber-Like Materials. R.H.V.M. Dawton, A.E.R.E. Report No. G/R 393.

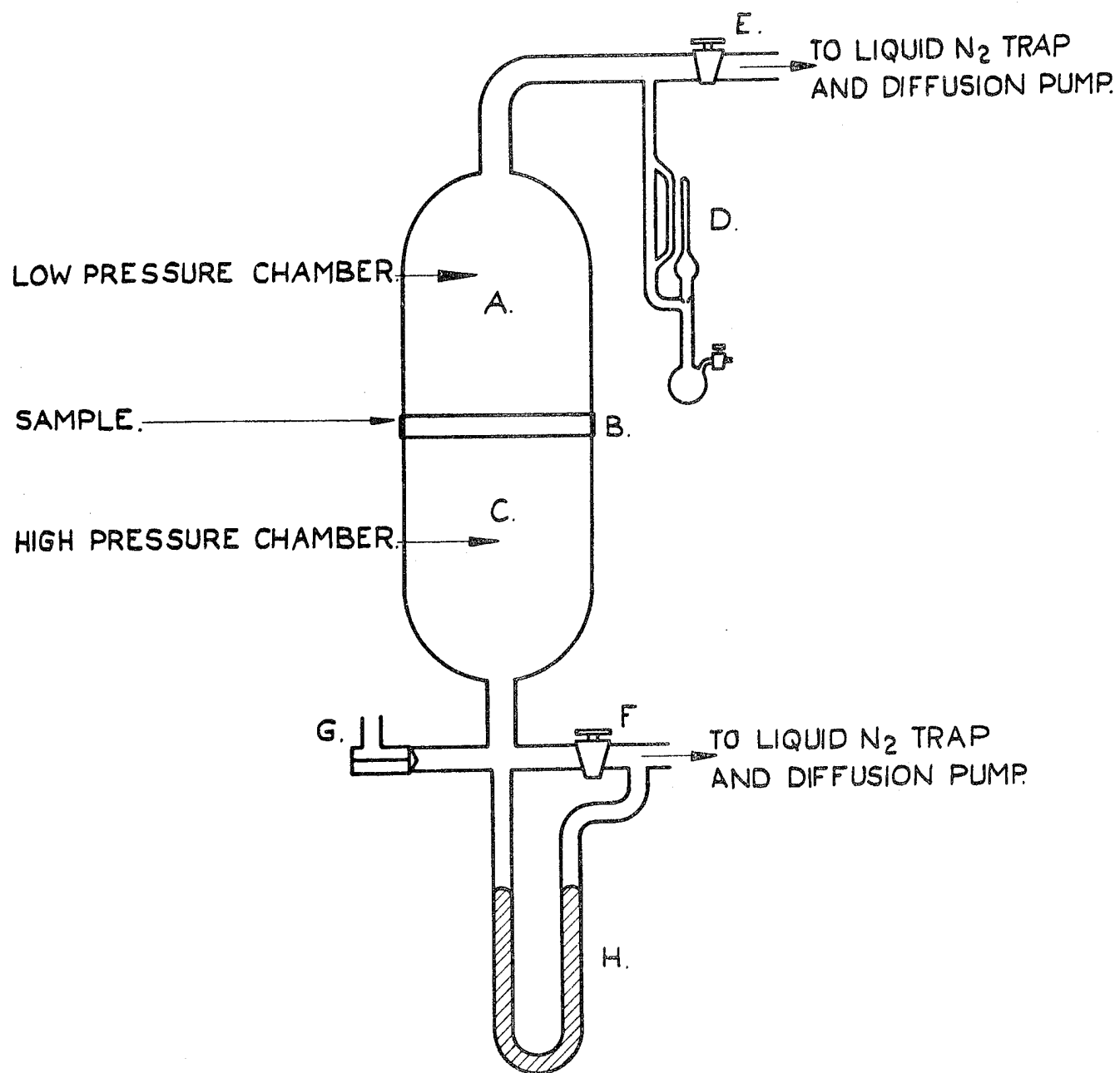
TABLE I

Permeability expressed in ccs at NP x cm<sup>-2</sup> x cm<sup>1</sup> (thickness)x secs<sup>-1</sup> x cm<sup>-1</sup> Hg measured at 23°C ± 1

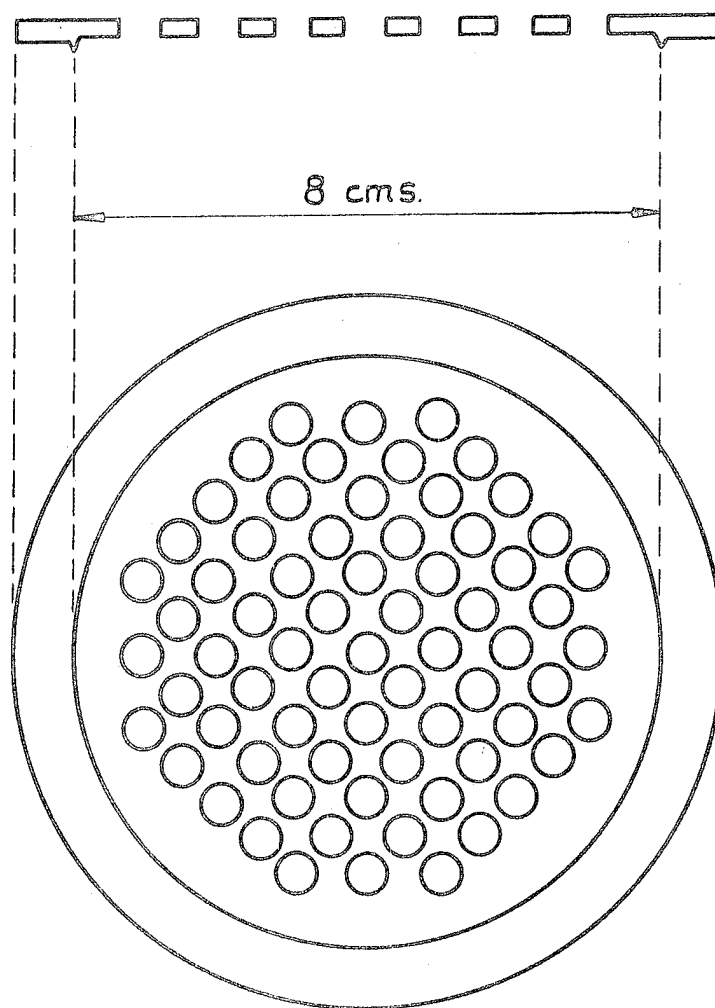
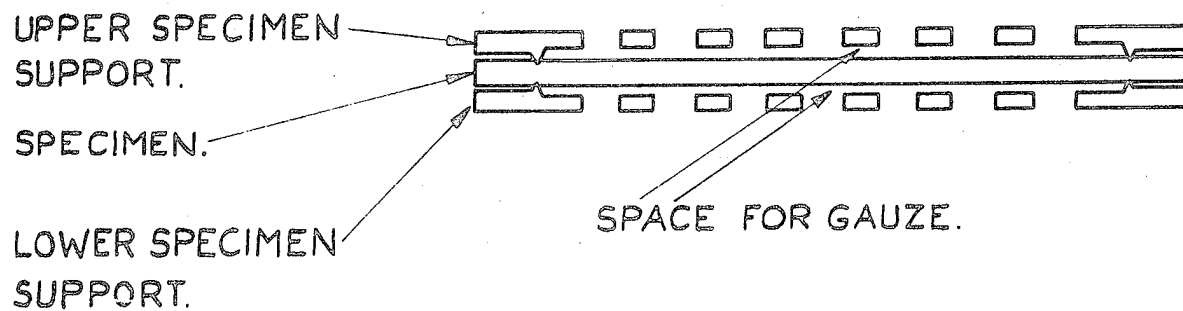
Material	H <sub>2</sub>	He	N <sub>2</sub>	O <sub>2</sub>	A
Polythene	1 x 10 <sup>-9</sup>	7 x 10 <sup>-10</sup>	1.2 x 10 <sup>-10</sup>	3.6 x 10 <sup>-10</sup>	3.3 x 10 <sup>-10</sup>
P.T.F.E.	2.4 x 10 <sup>-9</sup>	7 x 10 <sup>-8</sup>	3.1 x 10 <sup>-10</sup>	1 x 10 <sup>-9</sup>	5.8 x 10 <sup>-10</sup>
Perspex	3.3 x 10 <sup>-10</sup>	7 x 10 <sup>-10</sup>	*	*	*
Nylon 31	1.6 x 10 <sup>-11</sup>	3.7 x 10 <sup>-11</sup>	*	*	*
Nylon 51	6.3 x 10 <sup>-11</sup>	1.1 x 10 <sup>-10</sup>	*	*	*
Polyvinyltoluene (FVT)	2.0 x 10 <sup>-9</sup>	1.8 x 10 <sup>-9</sup>	*	7.7 x 10 <sup>-11</sup>	*
Polystyrene	1.6 x 10 <sup>-9</sup>	1.6 x 10 <sup>-9</sup>	*	6.3 x 10 <sup>-11</sup>	*

\*Below 1 x 10<sup>-11</sup>





A.E.R.E. M. 599. FIG. 1. APPARATUS USED FOR MEASUREMENTS OF PERMEABILITY.



A.E.R.E. M. 599. FIG. 2. SPECIMEN SUPPORT.

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