AIR AND WATER PENETRATION THROUGH WINDOWS: A DECADE OF TESTING

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SUMMARY

This report analyses the data obtained from windows tested for the manufacturing industry over the past ten years. The tests were conducted according to BS 4315:Part 1:1968 and the results compared with the stated performance levels given in B.S. Draft for Development 4:1971. Possible trends in design and performance are indicated.

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KEEPING THE ELEMENTS AT BAY

BS 4315 led to a marked improvement in window fittings, concludes *Thomas Provan*, reviewing 11 years of testing their resistance to the elements.

Resistance of window fittings to air and water penetration is governed by BS 4315, which since its publication in 1968 has come in for its fair share of criticism. But results from Paisley College of Technology show that the introduction of the standard has brought a vast improvement in window design and consequent cost savings in maintenance.

For the past 11 years the Fluids Group in the civil engineering department of the college has been testing windows with two main aims in view.

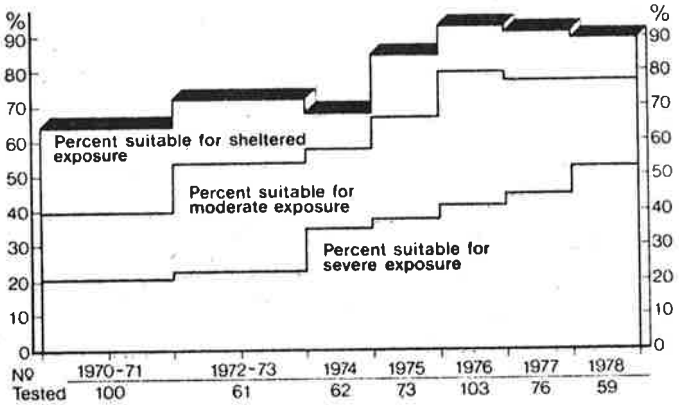
The first was to provide a service for the window manufacturing industry, whereby components were tested and their performance measured against the levels given in BS 4315, *Methods of test for resistance to air and water penetration: Part 1, Windows and gasket glazing systems*. 1968.

Allied to this were development projects generated both by the manufacturing industry and by government agencies. For example, an investigation of the various European test methods and their relative effects on window performance has recently been completed for the Building Research Establishment.

Results from tests undertaken for manufacturing industry over this 11-year period were collated and analysed for possible trends in design and performance.

Resistance to exposure was classified according to the grading structure given in the BSI's Draft for Development 4: 1971 *Recommendations for the grading of windows*. That recommends three grades of exposure, according to the maximum three-second gust speed to be expected in any particular area: sheltered, 40 m/sec; moderate, 45 m/sec; and severe, 50 m/sec.

Three-second gust speed for an area is provided from meteorological data and is defined as the maximum speed averaged over a period of three seconds at a once in 50 years probability.



Performance of the windows tested has shown a marked improvement

The overall performance of the 534 windows tested at Paisley is shown above.

The steady improvement in performance since the inception of BS 4315 is shown quite clearly. To summarise, the statistics from 1970 to 1978 show that the proportion of windows suitable for applications subject to severe exposure has risen from 21 to 53 per cent. In the same period the proportion suitable for moderate exposure has risen from 40 to 78 per cent, and those for sheltered applications from 64 to 90 per cent. Most important, however, is the decrease in the numbers of windows not suitable for any exposure – from 36 per cent down to 10 per cent.

A major difficulty that was encountered in the course of the work was achieving quality control.

BS 4315 recommends that a minimum of three units per 1000 be tested unless otherwise agreed between purchaser and supplier. In Scotland, practice has been for one sample of a given type to be supplied by the manufacturer. If not satisfactory, further examples are supplied until the required exposure category has been obtained.

This procedure can only be valid when reasonable quality control exists in the manufacturing process, and provided that reasonable care is employed in handling and installation on site. This was clearly demonstrated with three samples of similar windows tested prior to 1971. One sample almost achieved the severe category, one the moderate category, and one failed to reach sheltered category.

A range of window types was represented in the 534 samples tested. Horizontal pivot types formed 59 per cent, and 27 per cent were of side, top or bottom hung types. Timber frames were used in 78 per cent of windows tested.

The improvement in design over the years can undoubtedly be attributed to the greater awareness among architects and manufacturers of the deficienies shown up by the introduction of BS 4315. Prior to 1970, very few windows, for example, incorporated a weatherseal. The marked improvement in performance as this became a standard fitment is amply illustrated by Table 1. A second feature, uncommon at that time but now fairly standard, is top fixing for horizontal pivot type windows. The effect of these fitments, particularly when used in combination with weatherseals, is shown in Table 2.

In general then, the introduction of BS 4315 was of tremendous benefit. The proposed introduction this year of new test methods to replace those embodied in the standard can only lead to further improvements ●

Table 1: Effect of weatherseals on exposure suitability

Type	Total tested	Exposure suitability, % None	Sheltered	Moderate	Severe
All windows					
with weatherseal	433	8	92	75	43
without	101	68	32	19	7
Horizontal pivot					
with weatherseal	253	6	94	74	41
without	63	63	37	24	8
Side, top, bottom, hung					
with weatherseal	118	13	87	78	49
without	26	85	15	4	4

Table 2: Effect of top fixings and weatherseals on horizontal pivot windows

Type	Total tested	Exposure suitability, % None	Sheltered	Moderate	Severe
Top fixing and weatherseal	134	3	97	85	51
Weatherseal only	120	8	92	62	30
Top fixing only	18	33	67	44	17
Without top fixing or weatherseal	44	77	23	14	5

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INTRODUCTION

The Fluids Group of the Department of Civil Engineering at Paisley College of Technology has been engaged over the past eleven years in the field of window testing in two main areas of interest, viz.,

(1) provision of a service to the manufacturing industry whereby components are tested and the results compared with the stated performance levels given in B.S. 4315; Methods of Test for Resistance to Air and Water Penetration: Part 1; Windows and Gasket Glazing Systems: 1968.

(2) development projects arising both from the manufacturing industry and from Government agencies e.g. an investigation of the various European Test Methods and their relative effect on window performance has recently been completed for the Building Research Establishment.

The purpose of this report is to analyse the data obtained from the components tested for the manufacturing industry and to indicate possible trends in design and performance arising therefrom. The test facilities available at Paisley are described in M.A.C.D.A.T.A. Newsletter No. 3 which is available on request.

GRADES OF EXPOSURE

The British Standard Institution's Draft for Development 4:1971: Recommendations for the Grading of Windows, states that three grades of exposure should be recognised which are defined in terms of the maximum 3-second gust speeds to be expected in the particular area. The 3-second gust speed is provided by meteorological data and is defined as the maximum speed averaged over a 3-second period on a once in 50 year probability.

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The recommended grades of exposure are given in Table 1.

Exposure	Maximum 3-second Gust Speed (m/s)
Sheltered	40
Moderate	45
Severe (a)	50
Severe (b)	(55) *

TABLE 1: GRADES OF EXPOSURE

* Normally the upper limit for severe exposure should be taken at 50 m/s. The higher speed of 55 m/s is an assumed upper limit and is rarely necessary unless specified.

SELECTION OF SAMPLES FOR TEST

B.S. 4315 recommends that a minimum number of three units per thousand should be tested unless otherwise agreed between the purchaser and supplier.

In Scotland, the practice to date has generally been for one sample from a given type to be supplied by the manufacturer and provided this is satisfactory the purchaser accepts the results as applying to the complete batch. If not satisfactory, further samples are provided until the required exposure category has been obtained.

This procedure is only valid provided that reasonable quality control exists in the manufacturing process and provided reasonable care is taken on site in handling. This is clearly demonstrated in Fig. 1 which illustrates non-repeatability characteristics for three similar type windows tested prior to 1971.

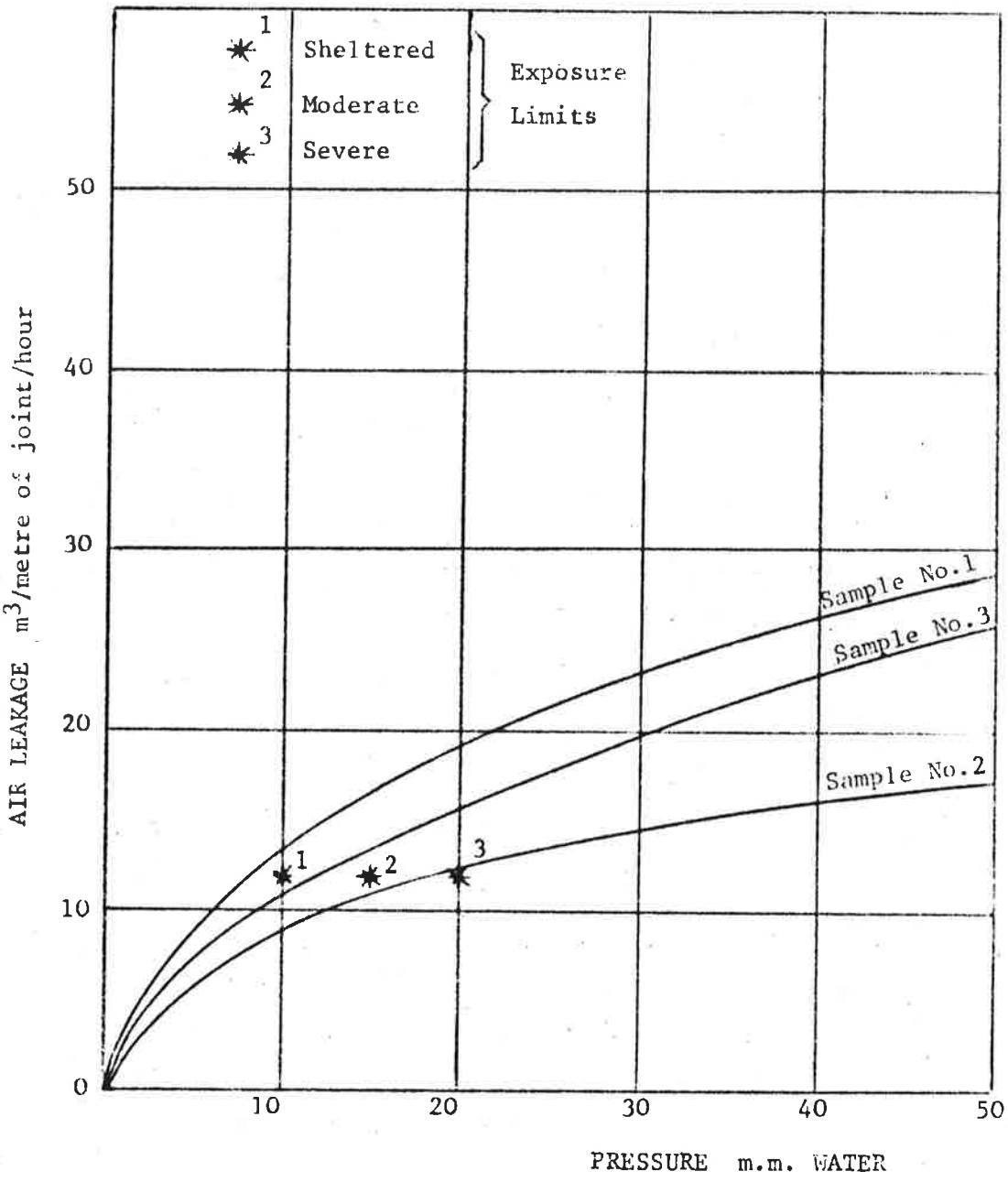

FIG. 1 : AIR PENETRATION FOR SIMILAR WINDOWS

DESCRIPTION OF SAMPLES TESTED

The distribution of the samples provided for test are given in Table 2 which indicates that over the past decade 534 windows have been tested at Paisley of which 59% were of the Horizontal Pivot type and 27% were of the Side, Top or Bottom Hung type. It is also worth noting that 78% of all windows tested were Timber framed.

Type	No. of Tests	Material	No. of Tests
Horizontal Pivot	316 (59%)	Timber	275 (87%)
		Metal	31 (10%)
		Aluminium	8 (3%)
		P.V.C.	2 (1%)
		Total	316 (100%)
Side Hung Top Hung Bottom Hung	144 (27%)	Timber	116 (81%)
		Metal	10 (7%)
		Aluminium	6 (4%)
		P.V.C.	12 (8%)
		Total	144 (100%)
Vertical Pivot	19 (4%)	Timber	16 (84%)
		Metal	2 (11%)
		Aluminium	1 (5%)
		Total	19 (100%)
Horizontal & Vertical Slider	47 (9%)	Aluminium	47 (100%)
Sash & Casement	8 (1%)	Timber	8 (100%)
TOTAL	534 (100%)		

TABLE 2: DISTRIBUTION OF TESTS

OVERALL PERFORMANCE ANALYSIS

The overall performance of the 534 windows tested at Paisley are tabulated in Table 3 and shown graphically in Fig. 2. These indicate that there has been a steady improvement in performance since the inception of B.S. 4315. In the period from 1970 to 1978, the statistics indicate that there has been an increase in windows suitable for

(a) severe exposure from 21% to 53%

(b) moderate exposure from 40% to 78%

(c) sheltered exposure from 64% to 90%

and a decrease in windows unsuitable for any exposure from 36% to 10%.

Year	Exposure Suitability				Total
	Severe	Moderate	Sheltered	None	
	No. of Tests				
≤ 1971	21 (21%)	40 (40%)	64 (64%)	36 (36%)	100 (100%)
1972-3	14 (23%)	33 (54%)	44 (72%)	17 (28%)	61 (100%)
1974	22 (35%)	36 (58%)	42 (68%)	20 (32%)	62 (100%)
1975	28 (38%)	49 (67%)	62 (85%)	11 (15%)	73 (100%)
1976	43 (42%)	82 (80%)	96 (93%)	7 (7%)	103 (100%)
1977	34 (45%)	59 (78%)	70 (92%)	6 (8%)	76 (100%)
1978	31 (53%)	46 (78%)	53 (90%)	6 (10%)	59 (100%)
TOTAL	193 (36%)	345 (65%)	431 (81%)	103 (19%)	534 (100%)

TABLE 3: PERFORMANCE ANALYSIS

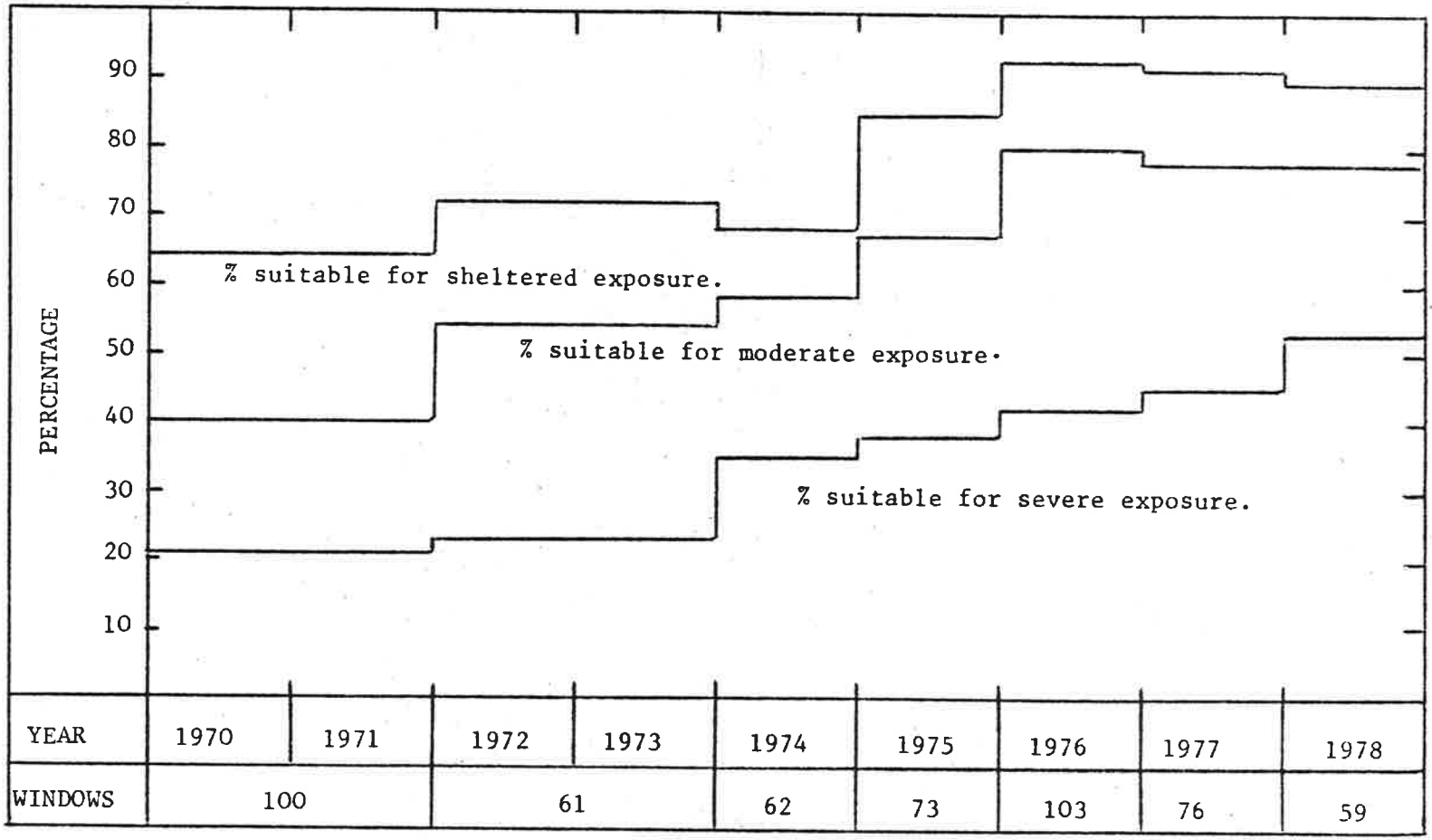

FIG. 2: PERFORMANCE ANALYSIS

EFFECT OF WEATHERSEALS AND TOP FIXINGS

The improvement in performance over the years is undoubtedly due to a greater awareness by architects and manufacturers of the deficiencies in design shown up by the introduction of B.S. 4315. Prior to 1970, very few windows incorporated a weatherseal. Top fixings on horizontal pivot type windows were uncommon. At the present time, both these features are fairly standard and there has been a marked improvement in performance. This is clearly illustrated in Tables 4 and 5 and in Fig. 3.

Type	Exposure Suitability				Total
	Severe	Moderate	Sheltered	None	
	No. of Tests				
ALL WINDOWS					
(a) with w/s	186 (43%)	326 (75%)	399 (92%)	33 (8%)	433 (100%)
(b) without w/s	7 (7%)	19 (19%)	32 (32%)	69 (68%)	101 (100%)
HORIZONTAL PIVOT					
(a) with w/s	104 (41%)	187 (74%)	239 (94%)	14 (6%)	253 (100%)
(b) without w/s	5 (8%)	15 (24%)	23 (37%)	40 (63%)	63 (100%)
SIDE, TOP, BOTTOM HUNG					
(a) with w/s	58 (49%)	92 (78%)	103 (87%)	15 (13%)	118 (100%)
(b) without w/s	1 (4%)	1 (4%)	4 (15%)	22 (85%)	26 (100%)

TABLE 4: EFFECT OF WEATHERSEALS

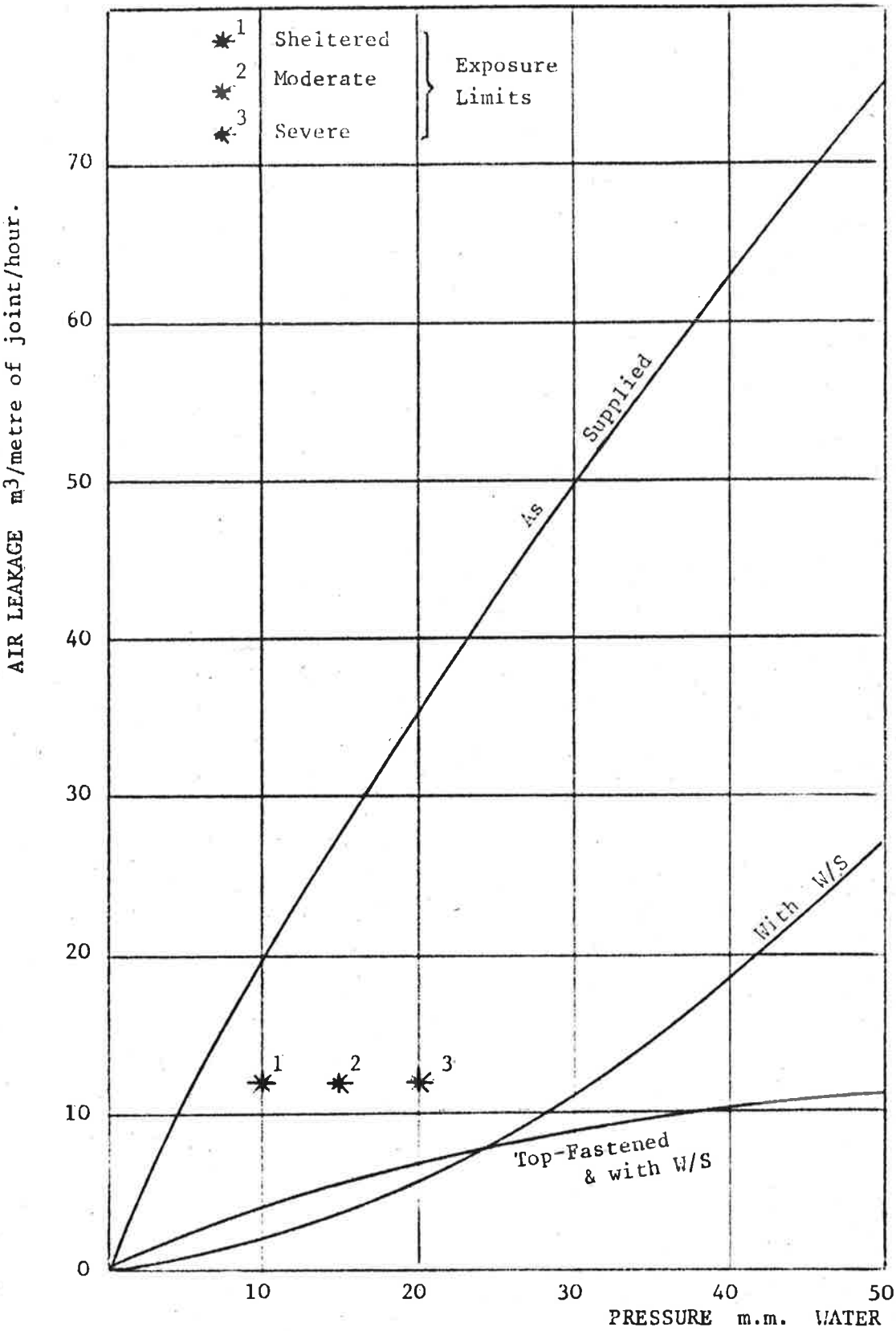

FIG. 3: EFFECT OF WEATHERSEAL & TOP-FASTENING

Horizontal Pivot	Exposure Suitability				Total
	Severe	Moderate	Sheltered	None	
	No. of Tests				
(a) with top fixing and w/s	68 (51%)	114 (85%)	130 (97%)	4 (3%)	134 (100%)
(b) w/s only	36 (30%)	74 (62%)	110 (92%)	10 (8%)	120 (100%)
(c) top fixing only	3 (17%)	8 (44%)	12 (67%)	6 (33%)	18 (100%)
(d) without top fixing or w/s	2 (5%)	6 (14%)	10 (23%)	34 (77%)	44 (100%)

TABLE 5: EFFECT OF TOP FIXINGS AND WEATHERSEALS ON HORIZONTAL PIVOT WINDOWS

CONCLUSIONS

B.S. 4315 has come in for its fair share of criticism over the years but there can be no doubt that its introduction has resulted in a vast improvement in window design and performance with a consequent saving in maintenance costs. The proposed introduction in 1979 of new Test Methods to replace B.S. 4315 can only further improve the situation.