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SORPTION ISOTHERMS OF TWELVE WOODS AT SUBFREEZING TEMPERATURES

BY

C. P. HEDLIN

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DIAGRAMMES D'ABSORPTION DE L'HUMIDITE PAR DOUZE VARIETES DE BOIS A DES TEMPERATURES CONSTANTES INFERIEURES A 32°F

SOMMAIRE

L'auteur a déterminé les diagrammes de teneur en humidité de douze variétés de bois soumises à l'éventail presque complet des degrés hygrométriques aux températures constantes de 10°F et 70°F.

Sous des conditions de faible humidité du milieu ambiant, la teneur hygrométrique du matériau à 10°F a dépassé celle du matériau correspondant à 70°F, conformément aux tendances notées précédemment pour les températures dépassant 32°F. Cependant, quand les échantillons ont atteint leur point d'équilibre hygrométrique dans une atmosphère à 10°F en contact avec de la glace, leur teneur hygrométrique a dépassé celle des échantillons plongés dans une atmosphère en contact avec de l'eau.

L'effet de retard a été notablement plus grand à 10°F qu'à 70°F. Le coefficient de retard du bois de sapin, par exemple, a atteint 0.70 pour un degré hygrométrique de 50% à 10°F et 0.79 à 70°F.

L'auteur a placé l'accent sur l'étude des diagrammes à température constante commençant soit à l'état de siccité, soit à l'état d'imbibition totale, bien que quelques expériences aient été menées à bien dans un éventail de degrés hygrométriques allant de 10 à 80 pour cent, sous des températures de 3°F et 70°F.

ANALYZED

Sorption Isotherms of Twelve Woods At Subfreezing Temperatures[1]

By

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WOOD IS ONE of the most commonly used building materials in Canada, and its moisture content in storage or service is of particular interest in many situations. Although its water vapor sorption characteristics at temperatures above 70°F. (2, 11) have been extensively investigated, little information is available about its equilibrium moisture characteristics below freezing (6), a condition that frequently occurs when it is incorporated in exterior walls or stored in unheated buildings in winter. For this reason, and because of the specific capability of instrumentation available, a number of different woods were included in a study of the equilibrium moisture contents of building materials at low temperatures at the Prairie Regional Station of the Division of Building Research in Saskatoon. Measurements were also undertaken at a temperature of 70°F. in order to correlate the results with those of other investigators.

Apparatus

The conditioned chamber in which the experiments were conducted consisted of an insulated air bath 24 inches in diameter and 14 inches deep. Brine was circulated between double-walled chambers that jacketed the test space. A resistance thermometer located in a well in the side of the bath sensed the temperature. A modulating control regulated the heat supplied to the refrigerated bath to control the brine temperature. In this way the air temperature was controlled within approximately ± 0.1 Fahrenheit degree. Humidity was regulated by calibrated Dunmore sensors connected to an electronic system actuating a valve.

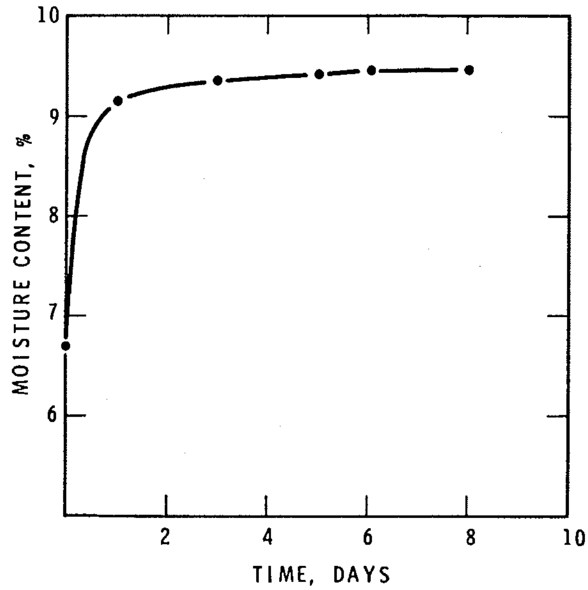

Figure 1. — Rate of change of moisture content of Douglas-fir shavings. Temperature 10°F. Relative humidity abruptly changed from 30 to 50 percent.

This, in turn, directed circulated air through either a desiccant or a humidifying tank. With this system the humidity level fluctuates less than 0.1 of 1 percent relative humidity (RH) about the set value and is considered to be accurate within ± 1/2 percent RH.

The samples, which ranged in weight from 1 to 2 grams, were placed in circular containers of 3-inch diameter and 3/4-inch depth. The sides and bottoms were made of 40-mesh stainless steel screen and aluminum plates were used as top covers. Each container was suspended by a stiff wire hooked over a hoop mounted in the bath. The hoop could be rotated from the outside and each sample was brought in succession to a position below a port in the top of the bath. The containers were suspended from the under side of an analytical balance for weighing to an accuracy within ± 1 milligram. As a check on possible variation in the weight of the containers from sorption of moisture or corrosion, one container was left empty. No net change in weight was normally observed. At the highest relative humidities, however, an increase of approximately 5 milligrams occurred. The same increase was assumed to occur in the weights of the other containers and a correction was applied to them.

Experimental Procedure

To shorten the time required for moisture exchange to take place, the wood samples were

[1]This paper is a contribution from the Division of Building Research, National Research Council, Canada, and is published with the approval of the Director of the Division. The author wishes to express his appreciation to G. O. Handegord and to the other members of the Division of Building Research who have given assistance and suggestions relative to this study, to J. Baldry for providing the wood specimens, and to R. W. Kennedy, Forest Products Laboratory, Vancouver, B.C., for his assistance in identifying the species.

This paper was received for publication in August 1966.

Table 1,a. — ADSORPTION AND DESORPTION EQUILIBRIUM MOISTURE CONTENTS FOR 12 WOODS (TEMPERATURE 10°F. UNLESS OTHERWISE INDICATED; RELATIVE HUMIDITY RANGE APPROXIMATELY 0 PERCENT TO NEAR SATURATION).

Relative humidity	Douglas-fir	Spruce	Poplar	Bald-cypress	Hard Maple	Philippine Mahogany	Bass-wood	West. Red Cedar	West. Red Cedar	Balsa	Black Walnut	Tama-rack	Sitka Spruce	Douglas-fir
							Adsorption							
13.3	4.5	4.6	4.0	4.1	4.2	4.5	3.7	4.3	4.2	3.5	3.8	4.6	4.4	4.5
26.6	6.8	7.0	6.2	6.1	6.5	6.9	5.8	6.3	6.2	5.6	5.8	6.9	6.8	6.7
44.4	9.6	10.0	9.2	8.5	9.5	9.7	8.5	8.5	8.5	8.3	8.1	9.9	9.6	9.6
61.7	12.1	12.9	12.3	10.7	12.8	12.4	11.4	10.4	10.6	11.2	10.3	12.9	12.6	12.2
75.5	15.1	16.7	16.3	13.7	16.8	15.8	15.1	13.0	13.3	14.9	13.3	16.9	16.2	15.4
85.1	17.8	20.1	19.9	16.0	20.4	18.7	18.7	14.9	15.3	18.1	15.9	20.3	19.5	18.0
100.0 (40°F.)	31.7	37.7	42.0	33.5	37.2	35.2	46.1	26.0	26.3	34.0	37.7	37.1	35.0	32.4
							Desorption							
85.0	25.1	27.7	26.9	23.8	28.5	26.8	27.1	23.1	23.4	26.7	25.0	27.5	27.2	25.4
76.5	21.8	23.6	22.6	21.3	24.4	23.4	22.4	21.3	21.5	22.3	21.4	23.3	23.1	22.1
71.5	20.5	22.0	21.0	20.1	22.9	22.0	20.7	20.1	20.4	20.7	20.0	21.8	21.6	20.8
61.3	17.4	18.4	17.0	16.9	18.8	18.3	16.7	17.1	17.4	16.8	16.6	18.3	18.0	17.5
44.1	13.5	14.0	12.6	12.9	14.0	14.0	12.3	13.2	13.5	12.3	12.7	13.9	13.7	13.5
28.1	10.3	10.7	9.4	10.0	10.5	10.8	9.2	10.1	10.3	9.0	9.8	10.7	10.6	10.5
17.7	7.8	8.2	7.0	7.7	7.4	8.3	6.9	7.9	8.2	6.8	7.7	8.3	8.2	8.1
9.0	5.6	5.8	4.9	5.4	5.4	5.7	4.7	5.4	5.6	4.6	5.2	5.8	5.8	5.7
2.9	3.7	3.7	3.0	3.5	3.4	3.8	3.1	3.5	3.7	3.0	3.4	3.8	3.8	3.8
0.0	0.0	0.05	0.0	—0.1	+0.1	+0.1	0.0	0.0	0.2	0.2	0.0	0.2	0.2	0.1
							Adsorption							
2.9	2.3	2.4	1.9	2.0	2.1	2.4	1.9	2.1	2.3	2.0	1.9	2.7	2.5	2.3
6.0	2.9	3.1	2.5	2.6	2.8	3.1	2.5	2.8	3.0	2.4	2.5	3.4	3.1	2.9
9.8	3.7	4.0	3.2	3.4	3.6	4.0	3.2	3.5	3.7	3.1	3.2	4.1	3.9	3.8
11.5	4.2	4.5	3.7	3.8	4.1	4.4	3.6	3.9	4.1	3.5	3.6	4.5	4.3	4.2
20.0	5.6	5.9	5.0	5.1	5.6	5.8	4.9	5.2	5.4	4.7	4.8	6.0	5.8	5.7
32.0	7.5	8.0	6.9	6.9	7.8	7.8	7.0	7.0	7.3	6.5	6.5	8.1	7.8	7.1
38.0	8.3	8.9	7.9	7.6	8.5	8.6	7.6	7.7	7.9	7.4	7.3	8.6	8.7	8.4

Table 1,b. — ADSORPTION AND DESORPTION EQUILIBRIUM MOISTURE CONTENTS FOR 12 WOODS AT APPROXIMATELY 3°F. (RELATIVE HUMIDITY RANGE 13 TO 81 PERCENT).

Relative humidity	Temp. °F.	Douglas-fir	Spruce	Poplar	Bald-cypress	Hard Maple	Philippine Mahogany	Bass-wood	West. Red Cedar	West. Red Cedar	Balsa	Black Walnut	Tama-rack	Sitka Spruce	Douglas-fir
							Adsorption								
40.6	3.5	11.1	11.3	11.2	10.8	10.9	11.1	9.6	8.4	8.8	9.1	9.5	11.4	11.1	11.2
62.0	3.5	13.1	13.9	14.0	12.6	14.1	13.4	12.1	10.1	10.4	11.5	11.1	14.0	13.7	13.4
81.0	2.5	17.4	19.9	20.1	17.0	20.5	18.7	18.3	14.2	14.4	17.8	15.5	20.3	19.5	17.7
							Desorption								
65.0	3.0	16.3	18.3	18.1	16.1	18.9	17.5	16.5	13.6	13.9	16.4	14.7	18.5	18.0	16.5
43.6	3.0	12.4	13.3	12.8	12.8	13.4	13.1	11.5	10.8	10.9	9.8	11.4	13.4	13.1	12.6
22.5	4.6	8.8	9.1	8.5	9.6	8.8	9.1	7.6	7.6	7.9	7.5	8.0	9.2	9.0	9.0
13.1	2.5	8.0	8.2	7.5	8.8	7.8	8.3	6.7	7.0	7.1	6.5	7.3	8.3	8.0	8.1
							Adsorption								
26.2	0.8	8.9	9.2	8.6	9.7	9.0	9.3	7.7	7.7	8.0	7.7	8.1	9.3	9.1	9.1
46.3	0.0	11.7	12.4	11.9	12.1	12.2	12.1	10.7	9.9	10.2	10.6	10.4	12.5	12.1	11.8
61.4	2.5	13.4	14.6	14.3	13.6	14.5	14.0	12.8	10.2	11.6	12.6	11.9	14.7	14.2	13.6
76.9	2.8	16.5	18.7	18.9	16.6	19.4	17.8	17.3	14.0	14.4	17.0	15.0	19.3	18.5	16.9
							Desorption								
64.7	2.2	15.5	17.5	17.3	15.2	18.0	16.7	15.8	13.2	13.6	15.7	14.0	17.8	17.1	15.9
43.0	2.2	12.1	13.1	12.4	12.6	13.1	12.8	11.2	10.6	10.9	11.3	11.2	13.2	12.8	12.3

cut into shavings about 0.010 inch thick, using a hand plane. The question may be raised as to whether the results obtained with thin specimens are valid for bulk wood. Christensen (1) observed that somewhat higher moisture contents were obtained with thin samples of mountain ash than with thicker pieces. This effect for his 180-micron samples was not significant, however, and, since this thickness is approximately the same as that used in the present work, it is taken as support for the validity of the assumption made here.

Initially, all the samples were dried at room temperature over anhydrous magnesium perchlorate in 12 by 12 inch glass jars until they reached constant weight. The humidity over anhydrous magnesium perchlorate corresponds to approximately −115°F. dewpoint. The results were accepted as dry weights, although Malmquist (8) suggests that about 0.3 percent moisture may still remain at this humidity. The samples were not heated because volatile components in some of the woods might be lost.

The dry samples were transferred quickly to the conditioned space and taken by steps through the humidity range. Following each change in humidity, the weights of the samples came relatively quickly to equilibrium for relative humidities below about 60 percent. Above this value the approach was asymptotic for both adsorption and desorption, and a longer period of exposure was needed. After about a day at 70°F. or a week at 10°F., the rate of change in most cases had decreased to about 0.03 percent moisture content per day (Fig. 1).

Results and Discussion

The equilibrium moisture contents for 12 woods are listed in Tables 1,a and 1,b for subfreezing temperatures, and in Tables 2,a and 2,b for a temperature of 70°F. All moisture contents were calculated on the dry weight basis. In each case the 'a' sections involved experiments covering the relative humidity range from nearly 0 percent to the highest value attainable in the apparatus; the 'b' section values were determined over a smaller range corresponding more closely to that to which woods are subjected in building structures. Following a desorption series of experi-

Table 2,a. — ADSORPTION AND DESORPTION EQUILIBRIUM MOISTURE CONTENTS FOR 12 WOODS AT 70°F. (RELATIVE HUMIDITY RANGE APPROXIMATELY 0 TO 99 PERCENT).

Relative humidity	Douglas-fir	Spruce	Poplar	Bald-cypress	Hard Maple	Philippine Mahogany	Bass-wood	West. Red Cedar	West. Red Cedar	Balsa	Black Walnut	Tama-rack	Sitka Spruce	Douglas-fir
						Desorption								
94.5	24.6	27.1	27.1	22.9	27.2	26.1	27.8	21.8	22.3	25.9	23.7	27.1	26.8	24.7
85.0	19.9	21.2	20.7	18.9	21.6	21.1	20.4	18.7	19.0	20.1	18.3	21.0	20.7	19.8
70.0	15.4	16.2	15.1	14.5	16.4	16.3	14.6	14.9	15.1	14.9	13.9	16.1	15.9	15.4
50.5	11.2	11.7	10.4	10.3	11.5	11.8	10.0	11.6	11.2	10.1	10.8	11.5	11.5	11.1
40.5	9.8	10.2	8.9	8.9	10.0	10.3	8.6	9.8	10.0	8.8	8.9	10.1	10.0	9.8
30.0	8.0	8.3	7.0	7.0	8.0	8.4	6.8	7.9	8.1	6.9	7.2	8.2	8.1	8.0
21.7	6.5	6.8	5.7	5.6	6.5	6.9	5.5	6.5	6.8	5.6	6.0	6.7	6.7	6.5
14.8	5.3	5.4	4.5	4.4	5.4	5.6	4.4	5.3	5.4	4.4	4.8	5.4	5.4	5.3
10.0	4.4	4.4	3.6	3.4	4.2	4.6	3.5	4.3	4.5	3.7	3.9	4.4	4.4	4.3
6.2	3.4	3.4	2.7	2.5	3.2	3.6	2.8	3.4	3.5	2.8	3.0	3.4	3.5	3.3
3.1	2.3	2.4	1.9	1.4	2.2	2.6	1.9	2.3	2.5	2.0	2.0	2.3	2.5	2.2
2.0	1.9	1.9	1.5	1.1	1.8	2.1	1.6	1.9	2.2	1.6	1.6	1.9	2.0	1.8
1.5	1.7	1.7	1.3	0.8	1.7	1.9	1.4	1.7	2.0	1.5	1.4	1.7	1.9	1.7
0.0	0.1	0.2	0.1	−0.7	0.4	0.4	0.1	0.2	0.4	0.4	.0	0.2	0.4	0.2
						Adsorption								
4.0	1.9	2.1	1.8	0.8	1.9	2.1	1.6	1.8	2.0	1.6	1.5	2.0	2.1	1.8
6.0	2.3	2.6	2.0	1.3	2.4	2.7	2.0	2.3	2.6	2.0	1.9	2.5	2.6	2.3
10.0	3.0	3.3	2.7	1.9	3.0	3.4	2.7	3.0	3.3	2.6	2.6	3.3	3.4	3.0
21.6	4.8	5.2	4.3	3.6	4.8	5.2	4.3	4.5	5.0	4.1	4.1	5.1	5.0	4.8
29.8	5.9	6.4	5.4	4.6	5.9	6.3	5.3	5.6	6.0	5.0	5.0	6.3	6.1	5.9
50.5	9.0	9.6	8.6	7.5	9.2	9.5	8.4	8.3	8.8	8.9	7.9	9.5	9.2	9.0
63.2	11.1	11.9	10.8	9.4	11.4	11.5	10.6	10.1	10.4	10.2	9.7	11.8	11.4	11.0
70.2	12.4	13.2	12.3	10.7	13.0	13.1	12.2	11.3	12.2	11.6	11.3	13.7	12.9	—
85.0	16.6	17.8	17.2	14.2	17.6	17.2	17.2	14.6	14.9	15.9	15.3	20.2	17.8	16.6
95.0	22.1	24.1	24.8	18.9	24.4	22.8	25.1	19.1	19.6	22.3	21.7	26.8	23.8	22.1
97.5	25.1	27.7	28.3	21.7	27.6	25.5	29.2	—	—	25.7	25.1	30.2	26.8	24.9
99.0	26.9	30.3	31.3	23.8	30.3	27.5	—	—	—	29.0	28.7	33.0	29.4	27.3

Table 2,b. — ADSORPTION AND DESORPTION EQUILIBRIUM MOISTURE CONTENTS FOR 5 WOODS AT 70°F. (RELATIVE HUMIDITY RANGE 8 TO 80 PERCENT).

Relative humidity	Douglas-fir	Spruce	Hard Maple	Philippine Mahogany	Oak
		Desorption			
20.3	6.6	6.5	5.4	5.8	5.2
8.3	3.9	3.7	3.3	3.5	3.1
		Adsorption			
20.4	5.9	5.8	5.5	5.6	4.8
39.9	8.4	8.6	7.4	8.1	7.3
60.5	11.7	12.6	10.9	11.7	11.0
79.7	14.4	16.9	15.2	15.1	15.2
		Desorption			
73.6	16.5	18.1	17.6	17.2	16.9
60.5	14.4	15.5	14.9	14.8	14.2
39.9	10.0	10.3	9.3	9.8	9.0
20.4	6.7	6.8	6.1	6.4	5.7
8.3	4.0	3.7	3.3	3.6	3.1

ments, the samples were again placed over magnesium perchlorate. As they did not generally return to exactly the original dry weight, the moisture contents corresponding to the deviation are recorded adjacent to the 0.0 percent RH value.

The relative humidities given in the tables of results for subfreezing temperatures are based on vapor pressures over supercooled water instead of vapor pressures over ice (except in Table 3, where both are given). Either basis is acceptable for reporting humidity and the selection of one or the other depends on the circumstances (3). In the present case, the selection of the supercooled water basis carries with it the implication that the sorbate is in the liquid phase even though it is at a subfreezing temperature. Consequently, it seems necessary to discuss briefly the reason for using it.

In a number of other cases problems of a similar nature have been studied. For example, the course

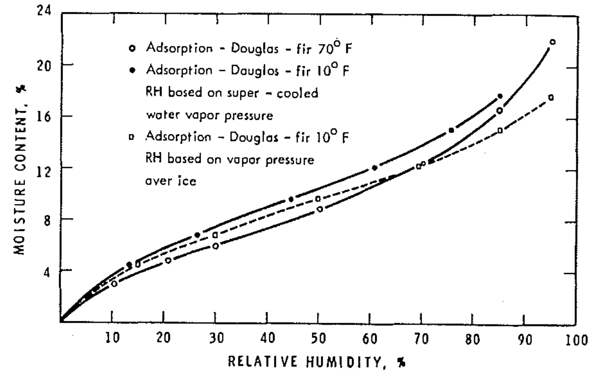

Figure 2. — Adsorption isotherms for Douglas-fir. The 10°F. isotherm is plotted using relative humidities based on the vapor pressure over ice and over supercooled water.

advocated above has been used successfully in correlating subfreezing and above freezing electrical resistance-relative humidity values for humidity sensors (4). There have been a number of reported studies of phase transitions in materials sorbed by inorganic materials (5, 7) including reports of apparent freezing below the bulk sorbate freezing temperature.

In the present case, when the data are plotted using relative humidities over ice, the 10°F. isotherms cross the 70°F. isotherms (Fig. 2) and, above the crossing point, lie at lower moisture levels than the 70°F. isotherms. On the other hand, when plotted against relative humidities based on supercooled water, the 10°F. isotherms show moisture contents higher than those of the 70°F. isotherms at any given relative humidity. The latter case is in accordance with the accepted trend for above freezing conditions and, superficially at least, appears to be the better way of describing the sorption behavior.

Since the vapor pressure over supercooled water is higher than it is over ice at a given temperature, the relative humidity corresponding to a given vapor pressure will be lower if referred to water (RH_w) than if referred to ice (RH_i). The relationship can be expressed:

Table 3. — ADSORPTION AND DESORPTION MOISTURE CONTENTS REACHED OVER ICE AT TEMPERATURES BETWEEN 10 AND 31.5°F. (RELATIVE HUMIDITIES GIVEN RELATIVE TO ICE AND SUPERCOOLED WATER).

Relative humidity: Ice	Relative humidity: Supercooled water	Douglas-fir	Spruce	Poplar	Baldcypress	Hard Maple	Philippine Mahogany	Basswood	West. Red Cedar	West. Red Cedar	Balsa	Black Walnut	Tamarack	Sitka Spruce	Douglas-fir	Temp. °F.
							Adsorption									
99.0	88.0	20.8	22.9	22.4	19.3	23.3	22.1	22.2	18.8	19.1	21.0	19.9	25.6	22.2	21.0	10.0
98.5	90.0	21.8	23.8	23.4	20.0	24.1	23.0	23.3	19.2	19.5	21.9	20.6	26.5	23.0	21.7	15.0
99.5	95.0	24.1	27.1	27.3	22.2	27.3	25.4	27.3	21.0	21.3	25.1	23.6	30.0	25.9	24.3	23.0
99.5	99.5	30.7	35.5	37.7	30.0	35.1	32.3	38.9	25.8	26.1	33.0	32.8	38.9	33.2	30.5	31.5
							Desorption									
99.5	95.0	27.9	31.4	30.8	25.6	31.4	29.3	31.7	24.5	24.8	29.5	28.1	34.5	30.4	28.0	23.0
98.5	90.5	26.8	29.9	29.3	24.9	30.4	28.3	29.9	24.0	24.3	28.4	26.9	32.7	29.2	26.9	16.5

$$\log_{10} \frac{RH_w}{RH_i} = 0.00234\ (t\text{-}32)$$

where t = temperature, °F. At 10°F., where most of the subfreezing work was done, the ratio is 0.888.

Table 3 contains the observed equilibrium moisture contents of wood samples exposed in the test chamber over an ice surface.

Measurements were made as the temperature was increased from 10 to 31.5°F., and subsequently decreased to 16.5°F. The measured relative humidity was about 99 percent relative to ice at all times. It was noted that the equilibrium moisture content changed substantially with temperature even though the relative humidity with respect to ice remained nearly constant.

The hysteresis ratios at 10°F. are much lower than those found at above-freezing temperatures. Most of them fall in the range between 0.6 and 0.7, compared with values 10 to 15 percent higher found at 70°F.

The results for white spruce agreed fairly well with those obtained by Spalt (9) at 90°F. and Stamm and Woodruff (10) at 77°F. The results for basswood differed from those obtained by Spalt by about 1 percent moisture content at the mid-point of the isotherms and somewhat less than this at the corresponding point on the desorption isotherm.

Kollmann (6) discusses the results obtained by varying the relative humidity over only a portion of its entire range. The results obtained in this work followed the pattern he indicated; for example, at 3°F. (Table 1,b) the moisture content of Douglas-fir varies by approximately 9 percent as the relative humidity is varied from 13 to 81 percent. This is roughly half the variation that would have occurred had the relative humidity been varied from 0 to 81 percent.

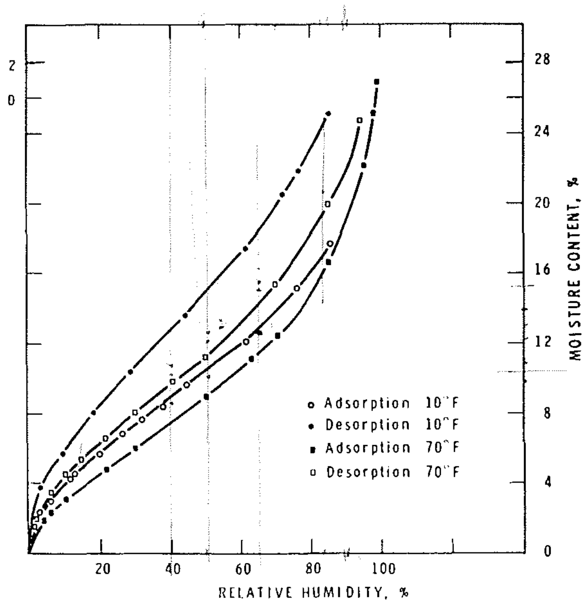

Figure 3. — Sorption data for Douglas-fir. Adsorption and desorption isotherms. Relative humidities at 10°F. are referred to supercooled water.

Table 4. — EQUILIBRIUM MOISTURE CONTENTS REACHED BY INITIALLY DRY MATERIALS SUBJECTED TO DIFFERENT INCREMENTS OF RELATIVE HUMIDITY AT 70°F.

Material	R.H.	E.M.C.				
Fir Shavings	10	3.5	3.5			
Do.	30	5.9	5.8	5.9		
Do.	50	8.7	(1)	8.5	8.7	
Do.	70	11.9	(1)	11.6	11.7	11.8
Wheat Straw	10	3.4	3.4			
Do.	30	5.7	5.6	5.6		
Do.	50	8.4	8.4	8.5	8.6	
Do.	70	12.8	12.7	12.9		13.1
Silica Gel	10	7.5	7.5			
Do.	30	17.6	17.7	17.3		
Do.	50	32.0	32.0	31.1	31.6	
Do.	70	39.2	38.7	38.2	39.3	38.7
Cellulose (Filter Paper)	10	2.7	2.7			
Do.	30	4.3	4.3	4.3		
Do.	50	6.1	6.1	6.1	6.1	
Do.	70	8.7	8.7	8.7	8.6	8.8

(1) Sample lost

As part of the study, a number of materials were subjected to step changes in relative humidity. In this series of experiments, which was carried out at 70°F., five samples of Douglas-fir, cellulose in the form of filter paper, and grain straw were initially dried over magnesium perchlorate, and five samples of silica gel were dried in an oven at about 260°F. One sample of each material was placed in the apparatus at about 5 percent relative humidity and the relative humidity was then gradually increased to 10 percent. At this time a second dry sample of each material was introduced and allowed to reach equilibrium. Following this, the relative humidity was increased to 30, 50, and 70 percent, and at each of these levels an additional dry sample of each of the materials was introduced. As is indicated in Table 4, no significant difference in the final moisture contents resulted from the difference in size of change.

Summary and Conclusions

Sorption data were obtained for 12 different types of wood at 3, 10, and 70°F. The isotherms obtained at 10°F. have the same shape as those obtained at 70°F., but at a relative humidity of about 99 percent relative to ice, the moisture contents reached at 10°F. were substantially lower than those reached at about the same relative humidity at 70°F. A practical consequence of this is that wood used as the exterior surface of a house or lumber stored outdoors will tend to have a moisture content below that of saturation during the winter season.

The equilibrium moisture contents at 70°F. are very nearly the same for all the woods up to a relative humidity of about 70 percent, differing by less than 3 percent moisture content. Above that value some gained more rapidly than others, and at a relative humidity of 99 percent (Table 2,a) the maximum difference was approximately 9 percent moisture content.

These data were obtained by measuring the moisture contents reached at a series of relative humidities. An approximate means of measuring the moisture content of woods could be employed by reversing the procedure, that is, measuring the equilibrium relative humidity and deducing the moisture content. Humidity measurement might be done by using commercially available devices designed to measure the humidities over hygroscopic materials. Unless the wood were known to be in an adsorbing or desorbing condition, the result would be only approximate because of the variation that is possible within the limits delineated by the isotherms.

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