per (unit area) (unit time). Such data may be called *water vapor transmission data* or WVT data and values are either high or low depending on the difference of vapor pressure chosen for the test. When this difference is known, WVT data can be converted to permeance, care being taken if conversion of the basic units (weight, area and time) is also required. The following formula applies:

$$\text{Permeance} = \frac{\text{WVT rating}}{\Delta p} \tag{11}$$

where,

WVT rating = weight of vapor transmitted, grains per (sq ft) (hour).
Δp = vapor pressure difference in the test, in inches of mercury.
Permeance is expressed in perms.

Table 21 presents the conversion factors applicable to the commonly used units and test methods.

Table 22 presents some data on typical building materials showing in each case the source and method and, where applicable, the thickness tested.

Water-proofed building papers are listed in *Federal Specifications* UU-P-147, May 24, 1948, according to water vapor resistance required as:

Class A. For uses where a high degree of water vapor resistance is required.
Class B. For uses where a lower degree of water vapor resistance and of water resistance is required.
Class C. For uses where a moderate degree of water resistance is required.
Class D. For uses where low resistance to water vapor is required.

It may be noted that a paper may be *water-proof* i.e. possess water resistance, and still have low water vapor resistance.

Detail requirements in these specifications are given as follows, the specified WVT Test being a dry method at 73F:

Class A paper shall have a minimum tensile strength in each direction of either 35 lb per inch width, or 20 lb per inch width, as specified in the invitation for bids. Paper of both strengths shall have a minimum water resistance of 24 hr; and a maximum water vapor permeability (WVT) of 4 grams per square meter per 24 hr, (i.e. 0.576 perm).

Class B paper shall have a minimum tensile strength in each direction of either 35 lb per inch width, or 20 lb per inch width, as specified in the invitation for bids. Paper of both strengths shall have a minimum water resistance of 16 hr, and a maximum water vapor permeability (WVT) of 6 grams per square meter per 24 hr, (i.e. 0.864 perm).

Class C paper shall have a minimum tensile strength in each direction of either 35 lb per inch width, or 20 lb per inch width, as specified in the invitation for bids. Paper of both strengths shall have a minimum water resistance of 8 hr.

Class D paper shall have a minimum tensile strength in each direction of 20 lb per inch width. The paper shall have a minimum water resistance of 10 min., a minimum water vapor permeability (WVT) of 35 grams per square meter per 24 hr, (i.e. 5.04 perms).

Concealed Condensation in Heated Buildings

Water vapor produced in a building necessarily raises the vapor pressure above that outside thus providing the force that causes its diffusion into exterior walls. The amount of vapor pressure rise in the building depends on the amount of vapor produced and inversely on its chance to escape. The resulting balance may be expressed in terms of relative humidity if the inside temperature is 70 F. The relative humidity in heated buildings

TABLE 22. PERMEANCE AND PERMEABILITY OF MATERIALS TO WATER VAPOR

MATERIAL	PERMEANCE PERM	PERMEABILITY PERM-INCH	% RH₁-RH₂	METHOD†	REF.‡
AIR (still)		120.	92-73	b	18
INSULATION					
Cellular glass		0.0		d	
Corkboard		2.1-2.6	75-0	d	21
Corkboard		9.5	100-45	w	24
Structural Insulating Board (vegetable, uncoated)		20-50	40-x	t	22
Mineral Wool (unprotected)		116.	100-30	w	19
WOOD					
Sugar Pine (see Fig. 7)		0.4-5.4	various	tv	18
Plywood (Exterior type 3 ply D.F.), ¼ in.	0.72		50-	4	26
Plywood (Interior type 3 ply D.F.), ¼ in.	1.86		50-	4	26
MASONRY					
Concrete (1:2:4 Mix)		3.2	100-45	w	24
Concrete (8" cored block wall, limestone agrgt.)	2.4		79-68	t	18
Brick wall—with mortar—4 in.	0.8		50-x	t	23
Tile wall—with mortar—4 in.	0.12		50-x	t	23
INTERIOR FINISH					
Plaster on wood lath	11.		100-30	w	19
Plaster on metal lath—¾"	15.		40-x	t	22
Plaster on plain gypsum lath (with studs)	20.		40-85	t	18
Gypsum wall board—plain—⅜ in.	50.		50-20	v	28
Insulating wall board (uncoated)—½ in.	50-90		40-x	t	22
* PAINT—2 coats					
Asphaltic paint on plywood	0.4		100-30	w	19
Aluminum in varnish on wood	0.3-0.5		95-0	d	25
Enamels, brushed on smooth plaster	0.5-1.5		92-0	b	18
Primers or *Sealers* on insulating wall board	0.9-2.1		40-x	t	22
Various *Primers* + 1 coat flat paint on plaster	1.6-3.		40-x	t	22
Flat paint (alone) on insulating wall board	4.		40-x	t	22
Water Emulsions on insulating wall board	30.-85.		40-x	t	22
* PAINT—Exterior, 3 coats					
White *lead & oil* prepared paint on wood siding	0.3-1.0		50-0	d	28
White lead-zinc oxide & linseed oil on wood	0.9		95-0	d	25

	Lb. per 500 sq ft	PERMEANCE-PERMS		
		dry cup	wet cup	
* BUILDING PAPERS AND FELTS				
Duplex sheet, asphalt laminae, *aluminum foil* one side	43	0.002	0.176	27
Saturated and *coated* felt heavy roll roofing	326	0.05	0.24	27
Kraft and *asphalt laminae*, Reinforced 30-120-30	34	0.3	1.8	27
Insulation back up, asphalt-sat., one side glossy	21	0.4	0.6-4.2	27
Asphalt-saturated and coated sheathing paper	43	0.3	0.6	27
Asphalt-saturated sheathing paper	22	3.3	20.2	27
15-pound asphalt felt	70	1.0	5.6	27
15-pound tar felt	70	4.0	18.2	27
Single sheet Kraft, double infused	16	30.8	41.9	27

* Description is a guide only, and does not insure permeance.

† Methods: d—dry cup; w—wet cup; t—two temperatures; b—special cell; v—air velocity both sides; 4—average of four methods.

‡ References. No. 22 also includes *Bulletins* 22 and 25 of the *Engineering Experiment Station, University of Minnesota*. No. 28 includes data to be published by the *Engineering Experiment Station, The Pennsylvania State College*.

covers nearly all of the possible range. In zero weather it may be only 10 percent in an office, and 85 percent in an industrial plant where humidification is required for a process, or where vapor release is incidental to a process. In residences the relative humidity in cold winter weather ranges from 10 percent to 60 percent, the latter figure applying to a very small, crowded and unventilated dwelling. A 40 percent level is considered representative of a substantial number of modern tightly constructed small houses although the average house relative humidity is probably below 25 percent. Surveys in residences show that the relative humidity increases