taken here, it may be said that there is not complete agreement in the results obtained by the different methods nor regarding a single standard to be used. Notwithstanding the uncertainties as to the theory and the lack of complete agreement as to test methods for measuring vapor permeabilities, the requirements are well understood and the relative values of certain types of materials have been established with sufficient precision to indicate their vapor permeability. Some values which may be used as a guide are given in Table 19.

TABLE 19. PERMEABILITY OF VARIOUS MATERIALS TO WATER VAPOR

Group	Material	Permeability Grains per (Sq Ft) (Hr) (Inch Hg)
1[a]	Plaster base and plaster, ¾ in.	14.7
	Fir sheathing, ¾ in.	2.9
	Waterproof paper[b]	49.1
	Pine lap siding	4.9
	Paint film	3.4
	Sugar cane fiberboard, ¾ in.	12.5
	Brick masonry, 4 in.	1.1
2[c]	Foil-surfaced reflective insulation, double-faced	0.08 to 0.13
	Roll roofing—smooth, 40 to 65 lb per roll 108 sq ft	0.13 to 0.17
	Duplex or laminated papers, 30-30-30	1.37 to 2.58
	Duplex or laminated papers, 30-60-30	0.52-0.86
	Duplex paper, coated with metallic oxides	0.52-1.29
	Insulation backup paper, treated	0.86-3.42
	Plaster, wood lath	11.00
	Plaster, 3 coats of lead and oil	3.68 to 3.84
	Plaster, 2 coats of aluminum paint	1.15
	Plaster, fiberboard or gypsum lath	19.73 to 20.57
	Plywood, ½ in., 5-ply Douglas fir	2.67 to 2.74
	Plywood, 2 coats of asphalt paint	0.43
	Plywood, 2 coats of aluminum paint	1.29
	Gypsum lath with metallic aluminum backing	0.09-0.39
	Insulating lath and sheathing, board type	25.68 to 34.27
	Insulating sheathing, surface-coated	3.03 to 4:36
	Insulating cork blocks, 1 in.	6.19
	Mineral wool, unprotected, 4 in.	29.07
	Sheathing paper, asphalt impregnated, glossy	0.17-2.05

[a] Calculating Vapor and Heat Transfer Through Walls, by L. G. Miller (*Heating and Ventilating* 35, No. 11, 56, November, 1938).

[b] Light weight slaters felt used to keep rain from drifting through. Not used as a vapor barrier.

[c] How to Overcome Condensation in Building Walls and Attics, by L. V. Teesdale (*Heating and Ventilating*, Vol. 36, No. 4, April, 1939).

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 only a moderate degree of water-vapor resistance or high water resistance is required.

Class C. For uses where only a moderate degree of water resistance is required.

Class D. For uses where high permeability to water vapor is required.

Detail requirements in these specifications are given as follows:

Class A paper shall have a minimum tensile strength in each direction of either 35 pounds per inch width or 20 pounds per inch width, as specified in the invitation for bids. Paper of both strengths shall have a minimum water resistance of 24 hours and a maximum water-vapor permeability of 4 grams per square meter per 24 hours.

Class B paper shall have a minimum tensile strength in each direction of either 35 pounds per inch width or 20 pounds per inch width, as specified in the invitation for bids. Paper of both strengths shall have a minimum water resistance of 16 hours, and a maximum water-vapor permeability of 6 grams per square meter per 24 hours.

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

Class D paper shall have a minimum tensile strength in each direction of 20 pounds per inch width. The paper shall have a minimum water resistance of 10 minutes and a minimum water-vapor permeability of 35 grams per square meter per 24 hours.

The method of test used to determine permeability as specified is the following:

The test specimen having an area of at least 50 square centimeters, shall be sealed on the mouth of a dish containing calcium chloride. The seal shall be made with wax composed of 60 per cent refined amorphous wax and 40 per cent of refined crystalline paraffin wax. The dish shall be exposed to an atmosphere of 73 F ± 3.5 deg and 50 ± 2 per cent relative humidity until a constant rate of gain in the weight of the dish is attained. The average constant weight of gain for at least four test specimens shall be reported as the water-vapor permeability of the material in terms of grams per square meter, per 24 hours. Both sides of the material, in equal number, shall be exposed towards the calcium chloride.

Surface Condensation Control

Since surface condensation is caused by water vapor coming into contact with the surfaces having temperatures below its dew point temperature, the obvious remedy is, first, to reduce as far as practicable the dew point temperatures of the surrounding vapors, and, second, to increase the temperatures of the surfaces with which these vapors may come in contact. The control of the dew point is usually an operating problem. It may be lowered by giving attention to source of the moisture and eliminating it before it comes in contact or mixes with the air in the space. It may also be effectively reduced by ventilation or by some moisture absorption process. The control of vapor formation and its elimination from the space as soon as possible is one of the first requirements in most condensation problems. It is often the complete remedy.

The temperatures of the surfaces with which the vapor comes in contact may be increased by adding insulation to outside walls, by double glazing of windows, by circulation of warmer air over the surface, or perhaps by direct heating of the surfaces. The most expedient method of overcoming surface condensation difficulty will depend upon special conditions surrounding the problem. This is a construction rather than an operating problem.

Control of Condensation Within Structure

Since condensation within the structure is really surface condensation transferred to the interior parts of the structure, the same precautions as to humidity control should be observed as for surface condensation. In addition to this, however, the structure must be built to prevent vapor from getting to the interior sections of a wall. A wall which is apt to have a cold interior section should be constructed with a vapor-resisting material on its warm surface.

There are many types of materials and methods of construction which may be used to vapor proof the interior surfaces of cold walls. Vapor resistant membrane materials are often built into the wall near the warm surface. In wood frame walls they may be applied to the inside surface of the studs. They are sometimes attached to the warm side of insulating materials or they may be applied on the cold side of plaster base materials. There are several types of vapor resistant papers in combination with metal foils which may be used. To be effective these barriers should have a reasonably high resistance to the passage of vapor and should be so applied that they are continuous and unbroken.

The interior construction of the wall may also be made of vapor resistant