PROPERTIES OF INSULATING FIBERBOARD SHEATHING

No. 2032

April 1955

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

PROPERTIES OF INSULATING FIBERBOARD SHEATHING

By R. F. LUXFORD, Engineer

Forest Products Laboratory,[1] Forest Service
U. S. Department of Agriculture

Introduction

Insulating fiberboard sheathing is used extensively in house construction. In 1920 insulating board accounted for only about 4 percent of the sheathing used for new residential construction. In 1940 its use had risen to 20 percent and by 1950 to 30 percent. It is more popular in certain regions of the country than in others. In 1950 about 50 percent of the wall sheathing used in the Middle West was of fiberboard, while in the Pacific Northwest where lumber is more easily obtained, insulating fiberboard sheathing was used in only about 10 percent of the new houses erected.

Insulating fiberboard sheathing has certain desirable characteristics that tend to increase its use. It is an excellent material for making a house wind-tight, its insulating properties are good, and because it comes in large sheets the cost of application is relatively low.

Wood fiber is the most common material used in the manufacture of insulating fiberboard. Two large companies use bagasse, while another company's board is composed mostly of waste paper. Flax shives are used to some extent by one manufacturer.

Information on the properties of some 14 different insulation fiberboards has been obtained by the Forest Products Laboratory.[2] They included all common commercial boards.

---

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] This work was done in cooperation with the Housing and Home Finance Agency.

Material

When possible, the material was purchased on the open market. Each type of fiberboard was represented by 3 sheets, usually 4 by 8 feet in size, although in some instances 2- by 8-foot sheets were furnished. With one exception, the boards were about 25/32 inch thick. The 25/32-inch boards were either impregnated or coated with asphalt. The single 1/2-inch board contained no asphalt.

Preparation of Test Specimens and Method of Test

Static bending strength, lateral nail resistance, direct nail-withdrawal resistance, linear expansion, and water absorption of the boards were established by test. The tests were made in accordance with the procedure outlined in American Society for Testing Materials Standard D1037-52T, entitled "Methods of Test for Evaluating the Properties of Fiber Building Boards." All specimens were conditioned at 75° F. and 64 percent relative humidity prior to test. The moisture content averaged about 9 percent.

The static bending specimens were 3 inches wide and 21 inches long. Specimens were cut with their long dimension either parallel or perpendicular to the long dimension of the fiberboard sheet. Three specimens were cut parallel and three were cut perpendicular from each kind of board. The bending specimens were tested over an 18-inch span and the rate of loading was 0.36 inch per minute (fig. 1). The moisture content and specific gravity of the bending specimens were determined at the time of test.

Tests for lateral nail resistance were made with sixpenny common wire nails driven at right angles to the face of the board. Tests were made with nails at two edge distances, namely, 3/8 and 3/4 inch from the edge of the board. Load was applied at the rate of 0.25 inch per minute (fig. 2).

Nail-withdrawal tests were also made with sixpenny common nails. The rate of loading was 0.06 inch per minute (fig. 3).

Linear-expansion tests were conducted on 3- by 12-inch specimens. Length measurements were made with the device shown in figure 4. The specimens were first conditioned for 2 weeks to equilibrium in an atmosphere of 50 percent relative humidity at 70° F. The length was then

measured with a dial micrometer reading to 0.001 inch. The specimens were then placed in an atmosphere of 97 percent relative humidity at 80° F. and conditioned for 1 month to bring them to equilibrium. The length of each specimen was measured immediately after this conditioning period, and the percentage increase in length, based on its length at 50 percent relative humidity, was determined.

Water-absorption tests were made on 12- by 12-inch specimens following conditioning for at least 2 weeks in a room held at 64 percent relative humidity and 75° F. The samples were then weighed and submerged horizontally under 1 inch of water maintained at a temperature of approximately 70° F. for 2 hours. After draining for 10 minutes the samples were again weighed.

Discussion of Results of Tests

Some of the more important results of tests on 14 different fiberboards are included in table 1. Figures 5 to 12, inclusive, show the relationship between specific gravity and various properties.

Bending Strength

The values for modulus of rupture, which is a measure of bending strength, averaged 379 pounds per square inch. The bending strength of most of the boards ranged between 250 and 450 pounds per square inch, as shown in figures 5, 6, and 7 and table 1. These values are for specimens whose length direction extended parallel to that of the fiberboard sheet. Similar tests were made on specimens whose length direction extended perpendicular to that of the fiberboard sheets, and the results were usually quite similar. The minimum value for modulus of rupture acceptable under the applicable federal specification[3] and commercial standard[4] is 224 pounds per square inch for 3/4-inch-thick boards and 336 pounds per square inch for 1/2-inch-thick boards. In general, the heavier boards were the stronger, but there was not a close correlation.

---

[3] Federal Specification LLL-F-321b for Fiberboard, Insulating, dated June 30, 1942.

[4] Commercial Standard CS42-49, "Structural Fiber Insulating Board."

Lateral Nail Resistance

Lateral nail resistance is of importance in resisting forces applied parallel to the plane of a sheathed wall panel. Thus, racking strength of a wall is closely related to the lateral nail resistance of the insulating fiberboard sheathing. The lateral nail resistance of the 14 insulating fiberboards fastened with sixpenny common nails spaced 3/8 inch and 3/4 inch from the edge is shown in figure 8 and 9. Of course, the lower values were obtained with the smaller edge distance. For a 3/8-inch edge distance most of the boards ranged between 30 and 80 pounds per nail, and for a 3/4-inch edge distance between 70 and 125 pounds. Specific gravity is a fair indication of the lateral nail resistance of various boards.

Direct Nail-withdrawal Resistance

The direct nail-withdrawal resistance of insulating fiberboards is low as compared to its lateral nail resistance. Figure 10 shows that the direct nail-withdrawal load varies, for a sixpenny common nail, from about 4 to 10 pounds. There is not a close relationship between specific gravity and direct nail-withdrawal resistance; rather, the boards tend to fall into two groups. For many uses the direct nail-withdrawal resistance of the fiberboard is not a factor.

Linear Expansion

The linear expansion of the various insulating fiberboards is extremely variable, and specific gravity of the board is not a good criterion, as is shown in figure 11. However, even those with a relatively high linear expansion are lower than the expansion of 0.5 percent permitted by the commercial standard.[3]

Water Absorption

The commercial standard[3] for insulating fiberboard places a limitation of 10 percent on water absorption for sheathing purposes. For purposes such as lath for plaster base, roof boards, and interior-finish board, the limitation varies from 7 to 10 percent. None of the boards investigated, as shown by figure 12, exceeded a moisture absorption of 2.2 percent.

Thermal Conductivity

No thermal conductivity tests were made on the 14 insulating fiberboards under investigation. However, tests on the same or similar boards, as reported by the American Society of Heating and Ventilating Engineers, show a k value varying from 0.33 to 0.40. The commercial standard[3] gives 0.40 as the maximum thermal conductivity, or k value, for sheathing boards. The k value is expressed in British thermal unit per hour per square foot per degree Fahrenheit per inch of thickness. In view of the ASH & VE test results, it was assumed that all 14 boards would meet the requirement for thermal conductivity.

General Discussion

The limiting bending-load value of the federal specification[2] and commercial standard[3] is based on the strength of dry material. As shown by figure 1, 13 of the 14 fiberboards tested met the federal specification. This board probably would also have passed had the rate of loading been as rapid as permitted by the federal specification or commercial standard.

While the wet strength of insulating fiberboard is of some importance, the specifications place no limitation on the strength of wet boards.

Insulating fiberboards frequently become wet during out-door storage at the building site, during erection, and in certain constructions during service. Preliminary tests indicated that immersion in water for 6 hours simulated the amount of wetting that can occur during construction or during winter in conventional frame walls having insulation and a good vapor barrier. A 48-hour immersion simulated the degree of wetting possible from condensation during cold weather in insulated houses located north of the January isotherm of 35° when a vapor barrier is absent or inadequate. The selection of the 48-hour soaking period for severe moisture conditions was influenced by the similarity of the average moisture content found in several different insulating fiberboards after soaking for 48 hours with that found in like materials under actual service conditions. These service-condition moisture values were obtained during the winter of 1939-40 in a small test house constructed on the roof of the Laboratory building at Madison, Wis. This one-story test house was of conventional wood-frame construction, with walls of plaster over gypsum lath for the inner face and insulating fiberboard sheathing under painted bevel siding for the outer face. A temperature of 70° to 72° F. and a relative humidity of 42 percent were maintained within the test house.

Soaking for 6 hours before test reduced the modulus of rupture and lateral nail resistance of the fiberboard to about 75 percent of the values for dry material. The moisture content was about 16 percent. When the material was soaked for 48 hours before test, the modulus of rupture and lateral nail resistance were reduced to about 40 percent of the values for dry material, and moisture content was about 45 percent.

Conclusions

The results of tests of the several properties investigated indicated that all 14 boards meet the commerical standard. The reductions in strength caused by wetting indicate that the insulating fiberboards should be kept dry during erection. Of even more importance is the necessity of keeping sheathing dry during service by the installation of good moisture barriers in those houses erected in parts of the country where moisture condensation is a problem.

Table 1. --Strength and related properties of various insulating fiberboards.

Board	Specific gravity[1]	Moisture content	Modulus of rupture[2] Dry	Lateral nail resistance[3] 3/8-inch edge distance	Lateral nail resistance[3] 3/4-inch edge distance	Direct nail withdrawal resistance	Linear expansion	Water absorption
		Percent	P. s. i.	Lb.	Lb.	Lb.	Percent	Percent
A	0.297	9.0	447	66	124	7.8	0.22	1.82
B	.282	8.2	391	77	123	10.0	.20	1.66
C	.266	9.7	204	44	82	5.3	.24	1.64
D	.252	11.0	246	32	52	5.0	.24	1.41
E[4]	.389	11.6	760	73	90	7.4	.42	2.22
F	.342	7.2	788	94	157	11.3	.34	1.41
G	.282	8.6	231	53	85	8.4	.27	1.22
H	.282	9.6	320	74	114	7.8	.31	1.74
I	.242	9.0	285	37	74	5.6	.27	1.45
J	.274	9.4	316	59	110	8.2	.33	1.64
K	.283	9.5	371	83	141	9.4	.47	1.78

(Sheet 1 of 2)

Table 1. --Strength and related properties of various insulating fiberboards. (continued)

Board	Specific gravity[1]	Moisture content	Modulus of rupture[2]	Lateral nail resistance[3]		Direct nail drawal resistance	Linear expansion	Water absorption
			Dry	3/8-inch edge distance	3/4-inch edge distance			
		Percent	P. s. i.	Lb.	Lb.	Lb.	Percent	Percent
L	0.238	9.3	268	41	70	4.1	0.26	1.93
M	.251	7.7	320	63	95	3.6	.48	1.68
N	.272	8.8	356	61	103	10.0	.29	1.13
Av.	.282	9.2	379	61	101	7.4	.31	1.62
Fed. Spec. LLL-F-321b			224				.5	

[1] Based on weight when ovendry and volume at time of test.

[2] Based on specimens cut with lengthwise dimension parallel to length of fiberboard.

[3] Average of specimens cut lengthwise and crosswise of fiberboard.

[4] 1/2 inch thick.

(Sheet 2 of 2)

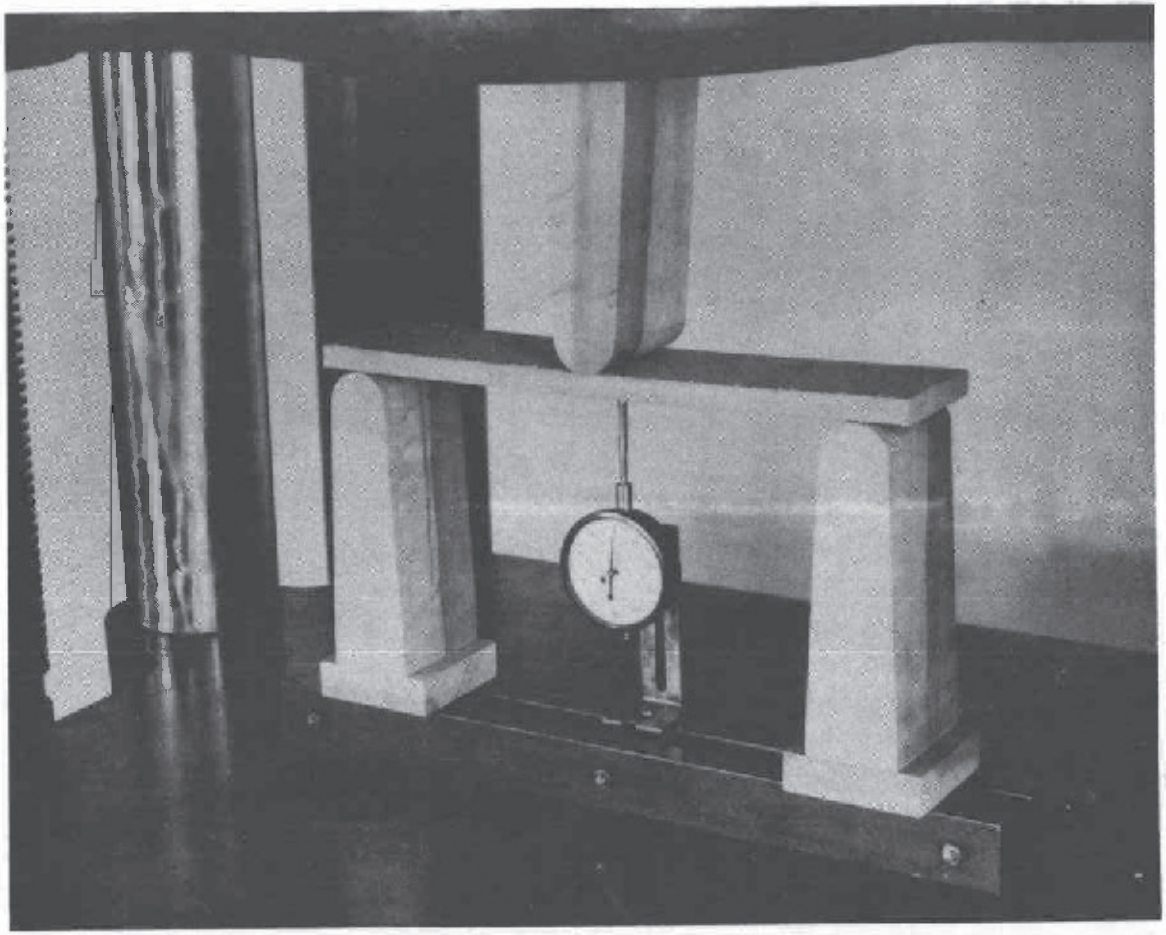


Figure 1. --Static bending test of insulating fiberboard.

Z M 77050 F

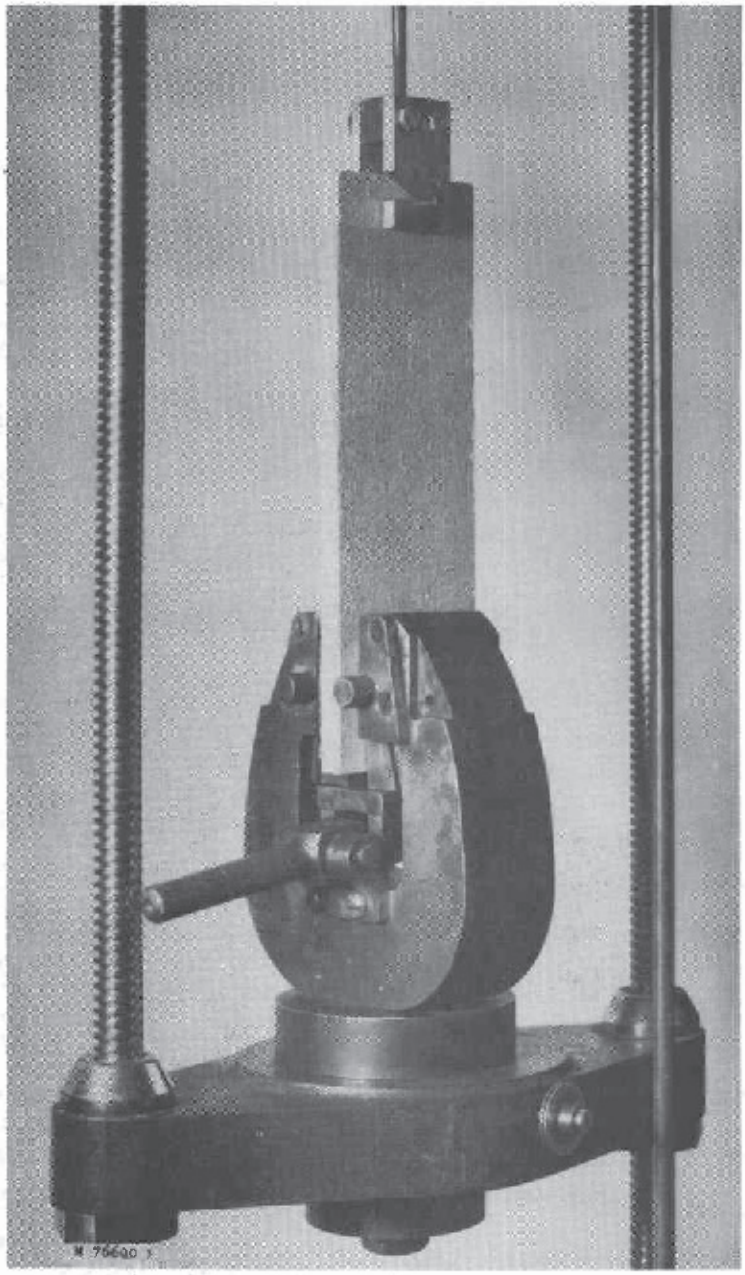


Figure 2. --Test setup for determining resistance of insulating fiberboard to lateral loads applied through nails.

Z M 76600 F

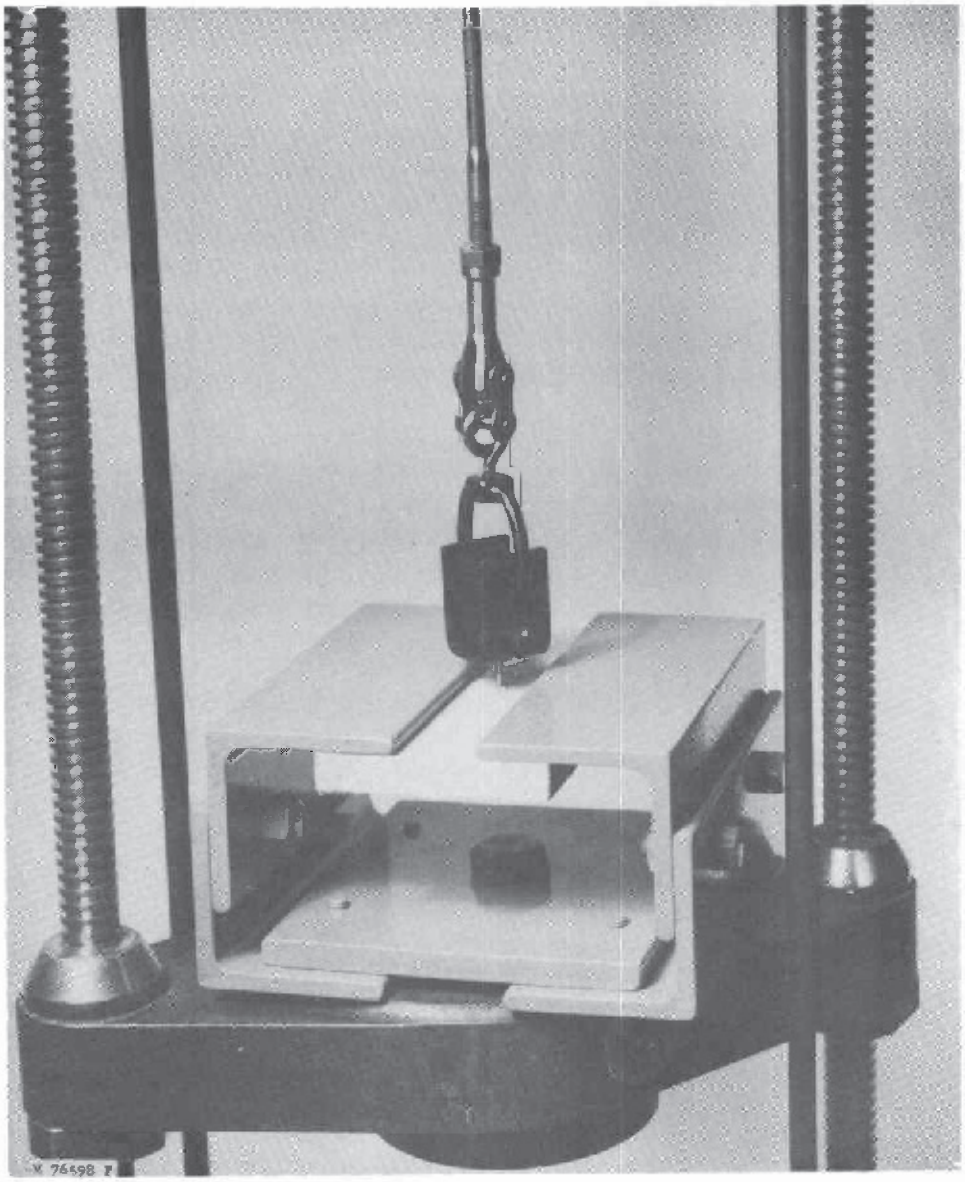
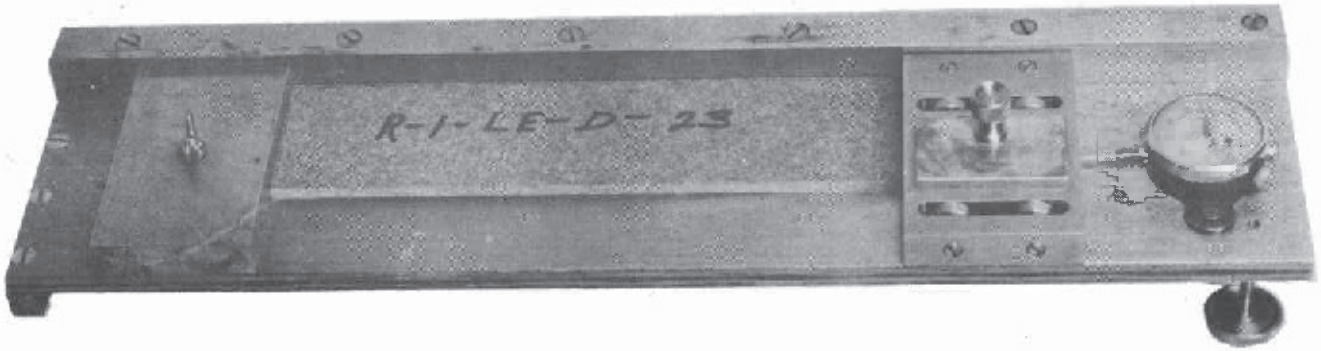


Figure 3. --Test setup for determining resistance of insulating fiberboard to direct withdrawal of nails.

Z M 76598 F



Z M 86365 V

Figure 4. --Method of measuring linear expansion of insulating fiberboards.

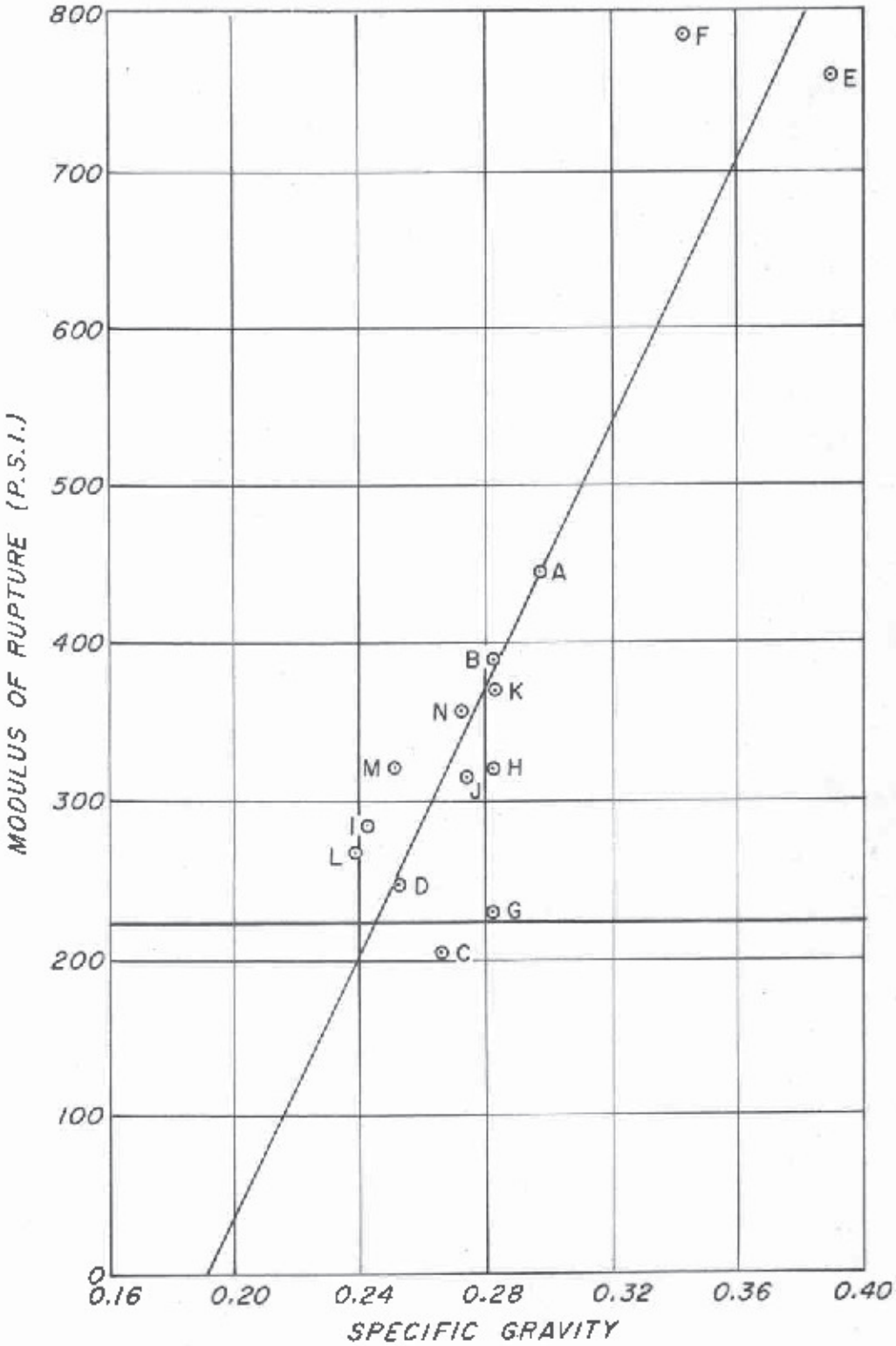


Figure 5. --Modulus of rupture as related to specific gravity of insulating fiberboards tested dry. Horizontal line is lower limit of 224 pounds per square inch set by CS42-49.

Z M 105 599

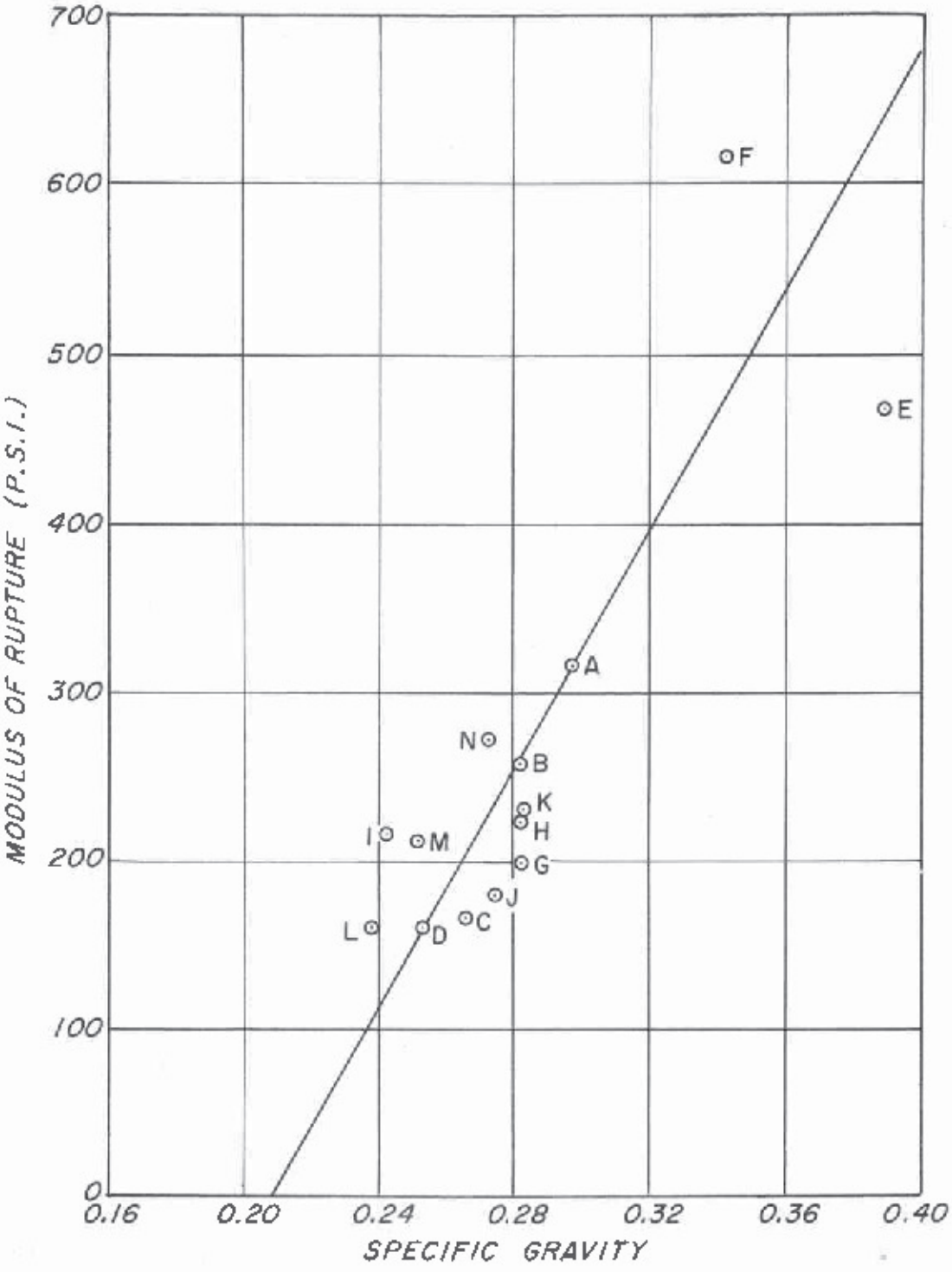


Figure 6. --Modulus of rupture as related to specific gravity of various insulating fiberboards, after soaking 6 hours.

Z M 205 600

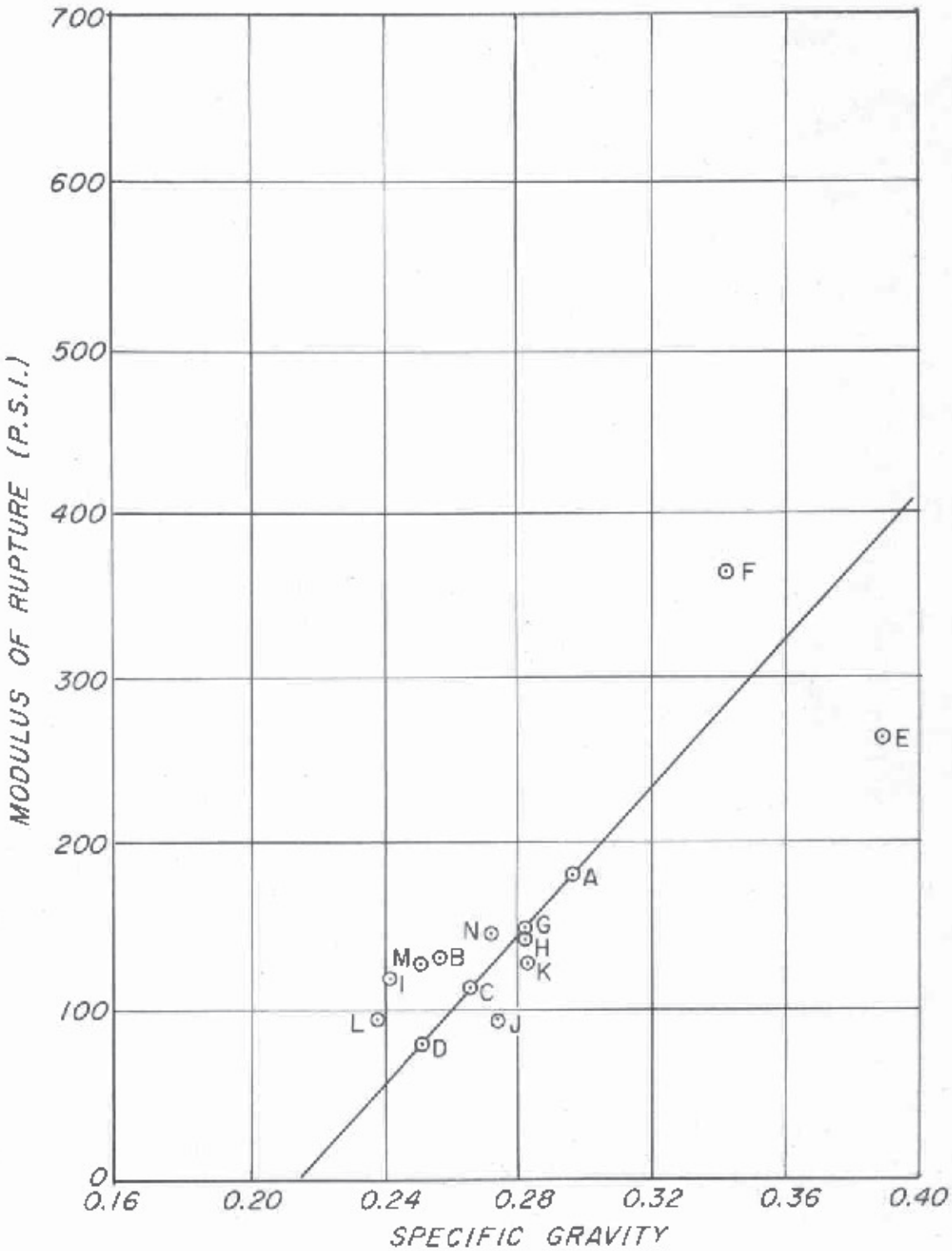


Figure 7. --Modulus of rupture as related to specific gravity of various insulating fiberboards, after soaking 48 hours.

Z M 105 601

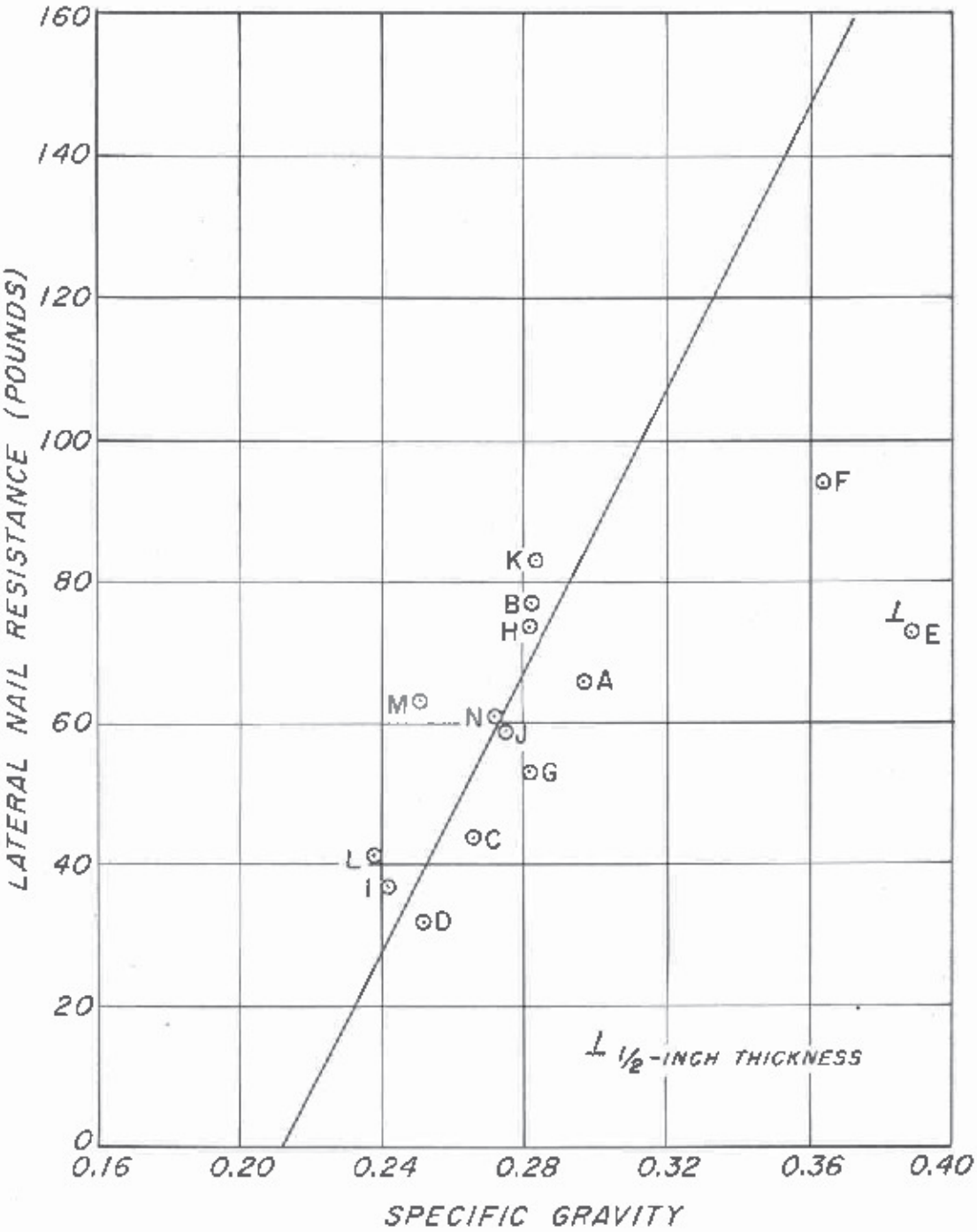


Figure 8.--Lateral nail resistance as related to specific gravity of various 25/32-inch insulating fiberboards. Nails driven 3/8 inch from edges.

Z M 105 602

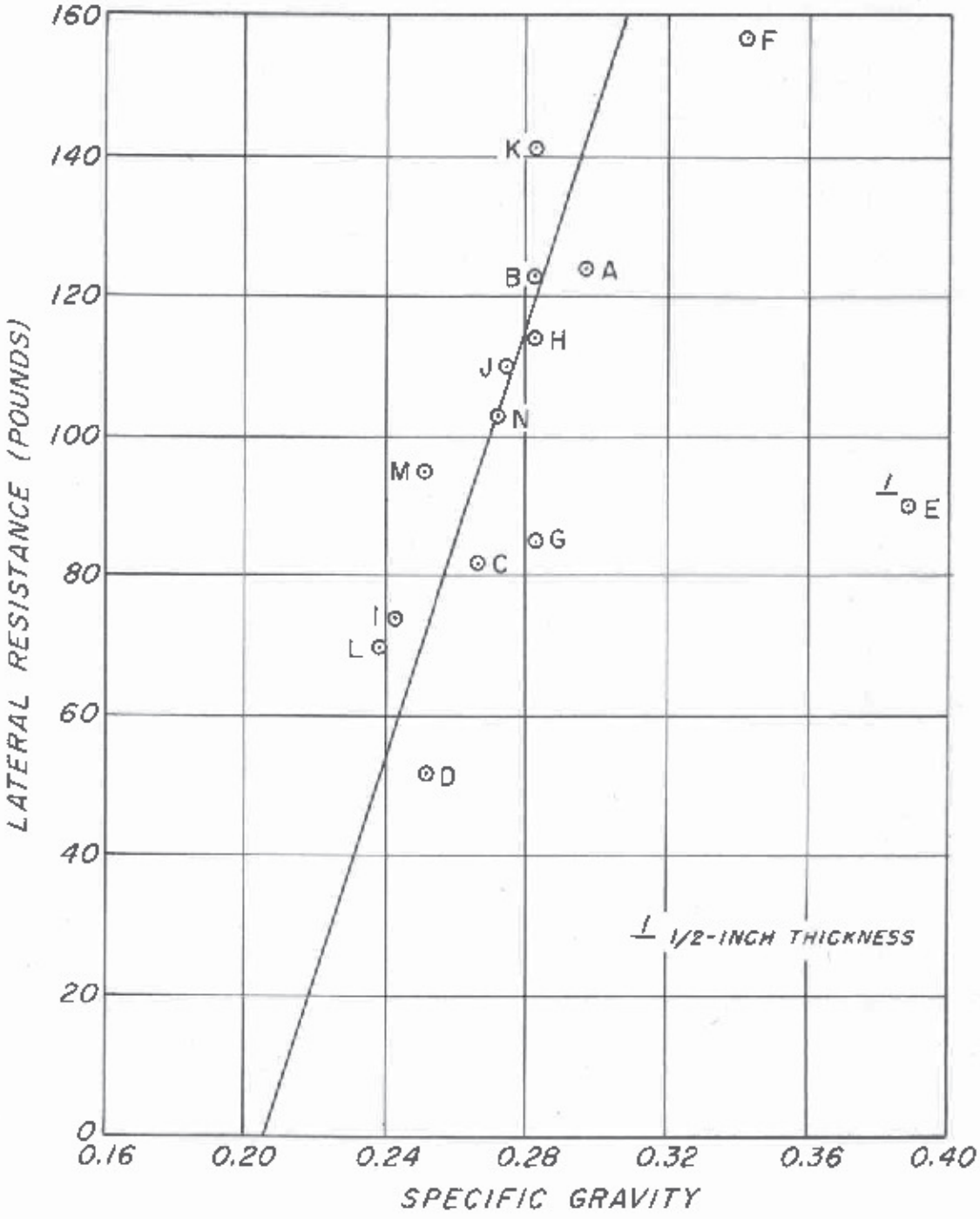


Figure 9. --Lateral nail resistance as related to specific gravity of various 25/32-inch insulating fiberboards. Nails driven 3/4 inch from edges.

2 X 105 603

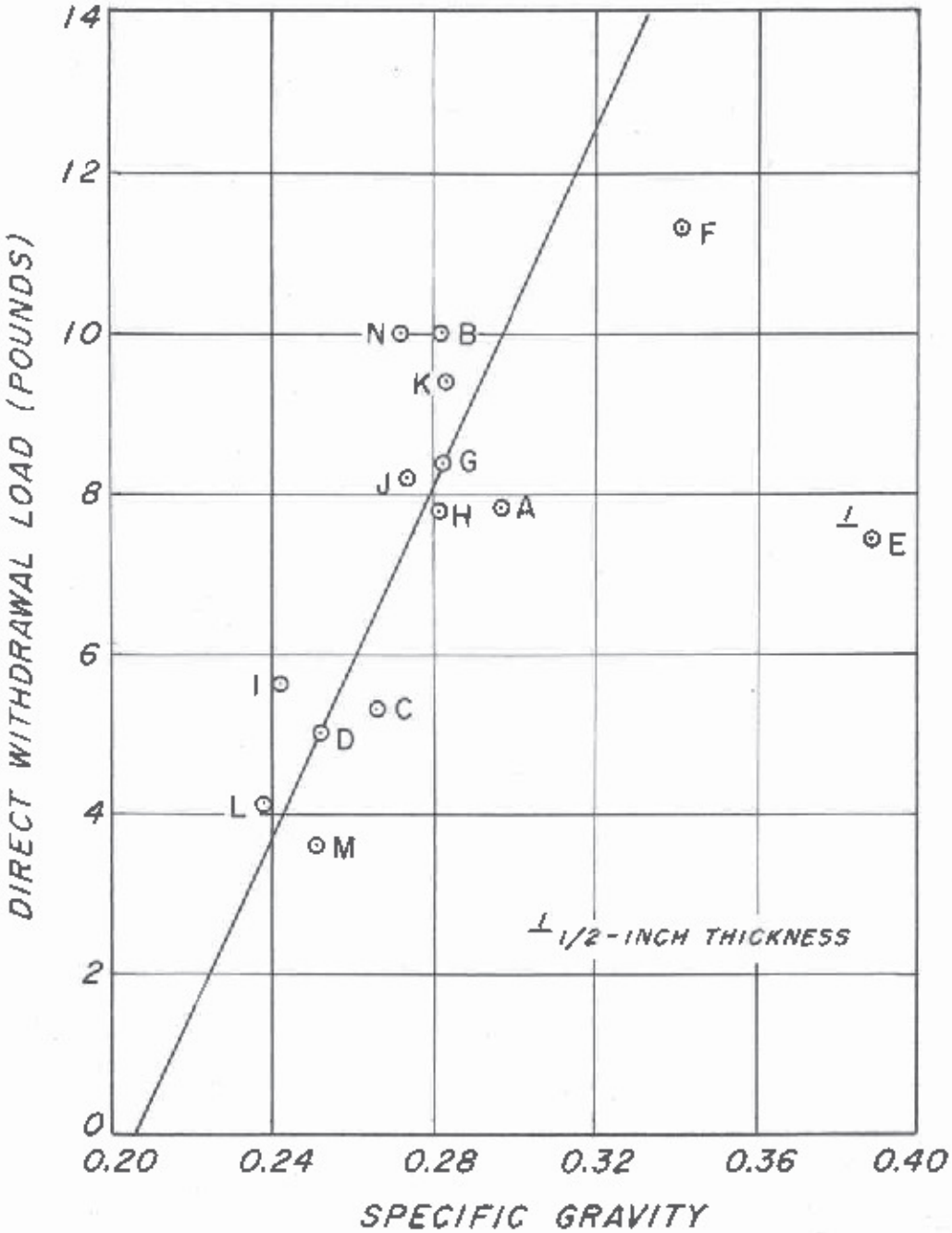


Figure 10. --Direct nail-withdrawal load as related to specific gravity of various 25/32-inch insulating fiberboards.

Z M 105 604

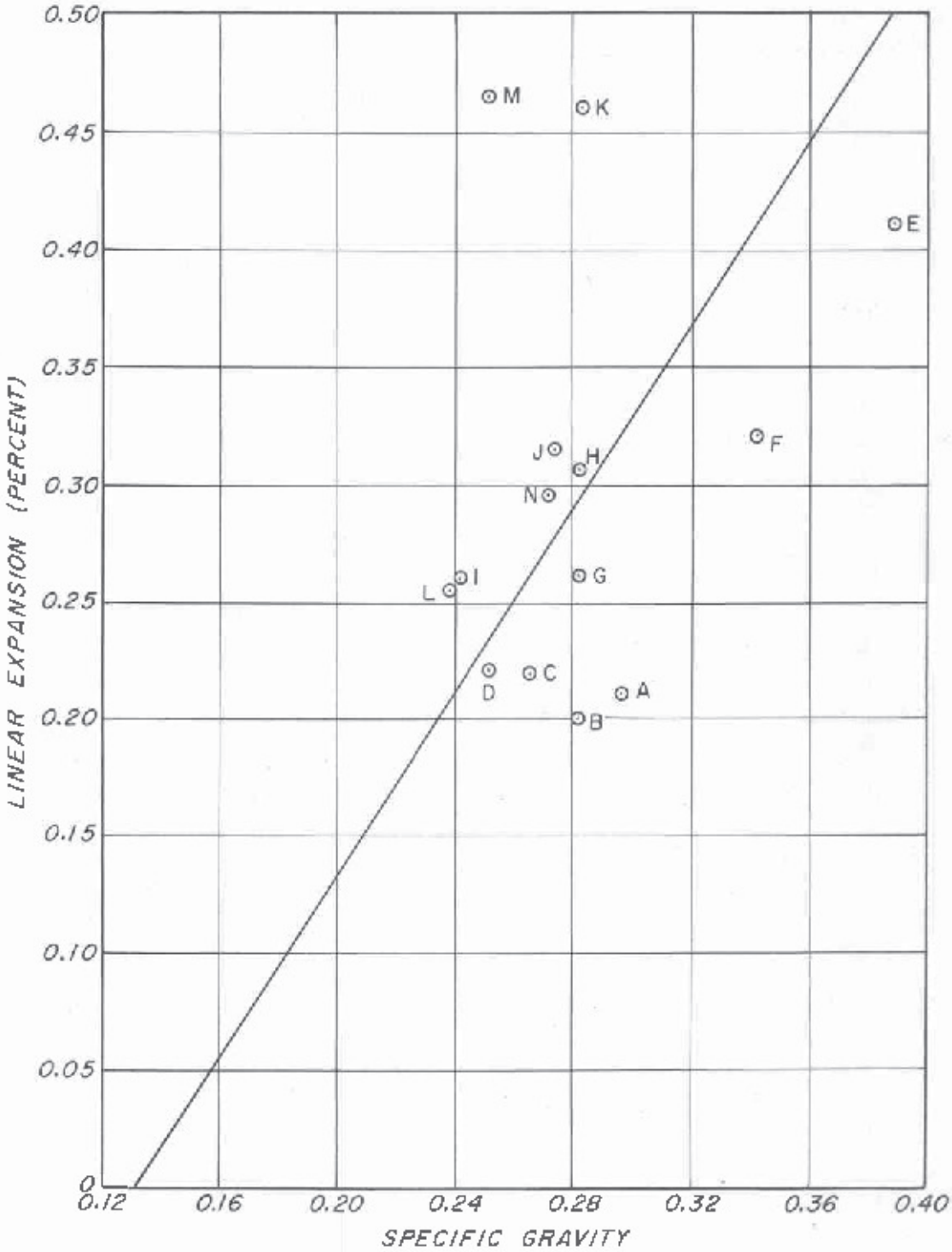


Figure 11.--Linear expansion as related to specific gravity of various insulating fiberboards.

Z M 105 605

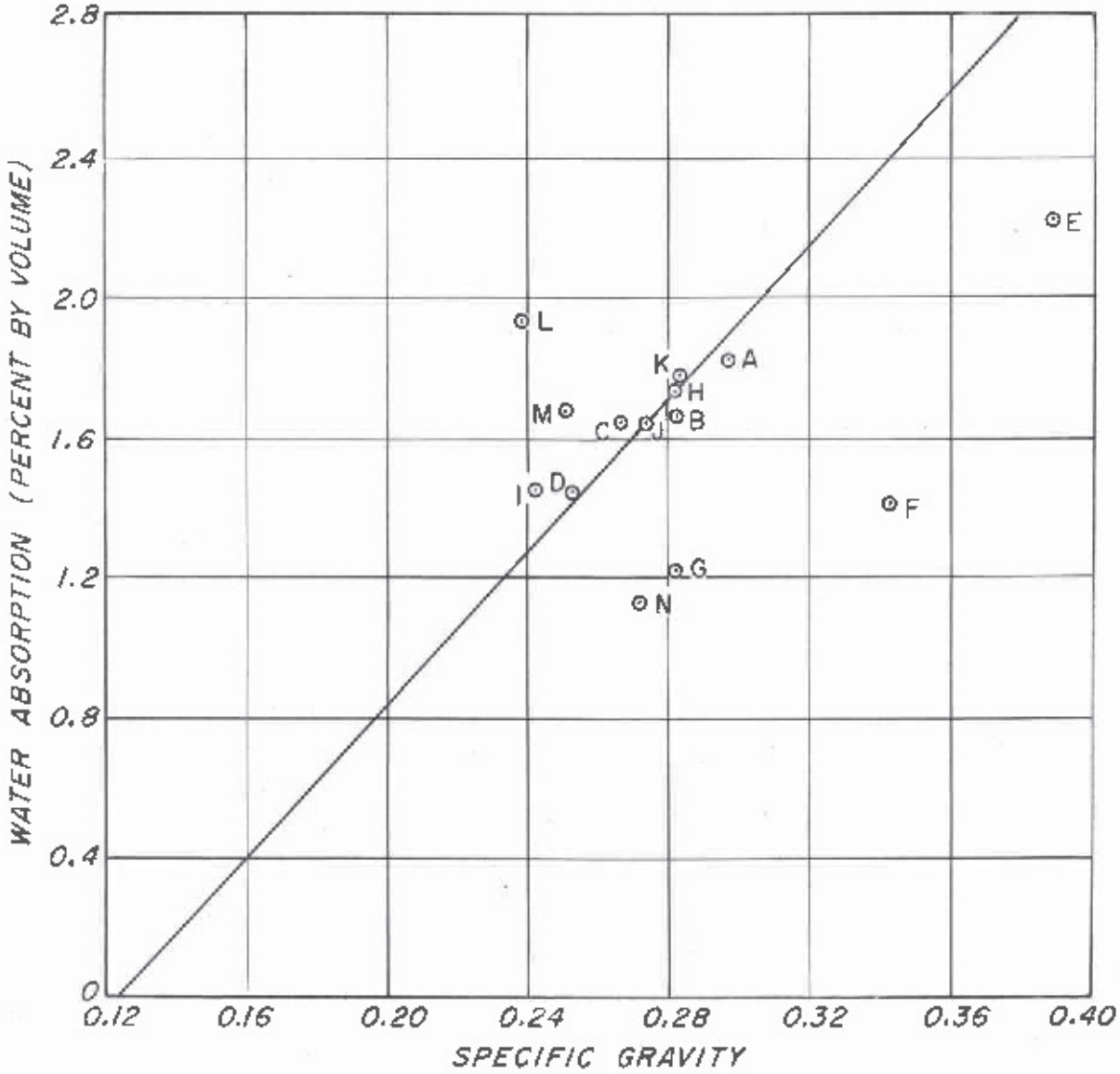


Figure 12. --Water absorption as related to specific gravity of various insulating fiberboards.

Z M 105 605