

106-86

CROSS REFERENCE

EXAMINER

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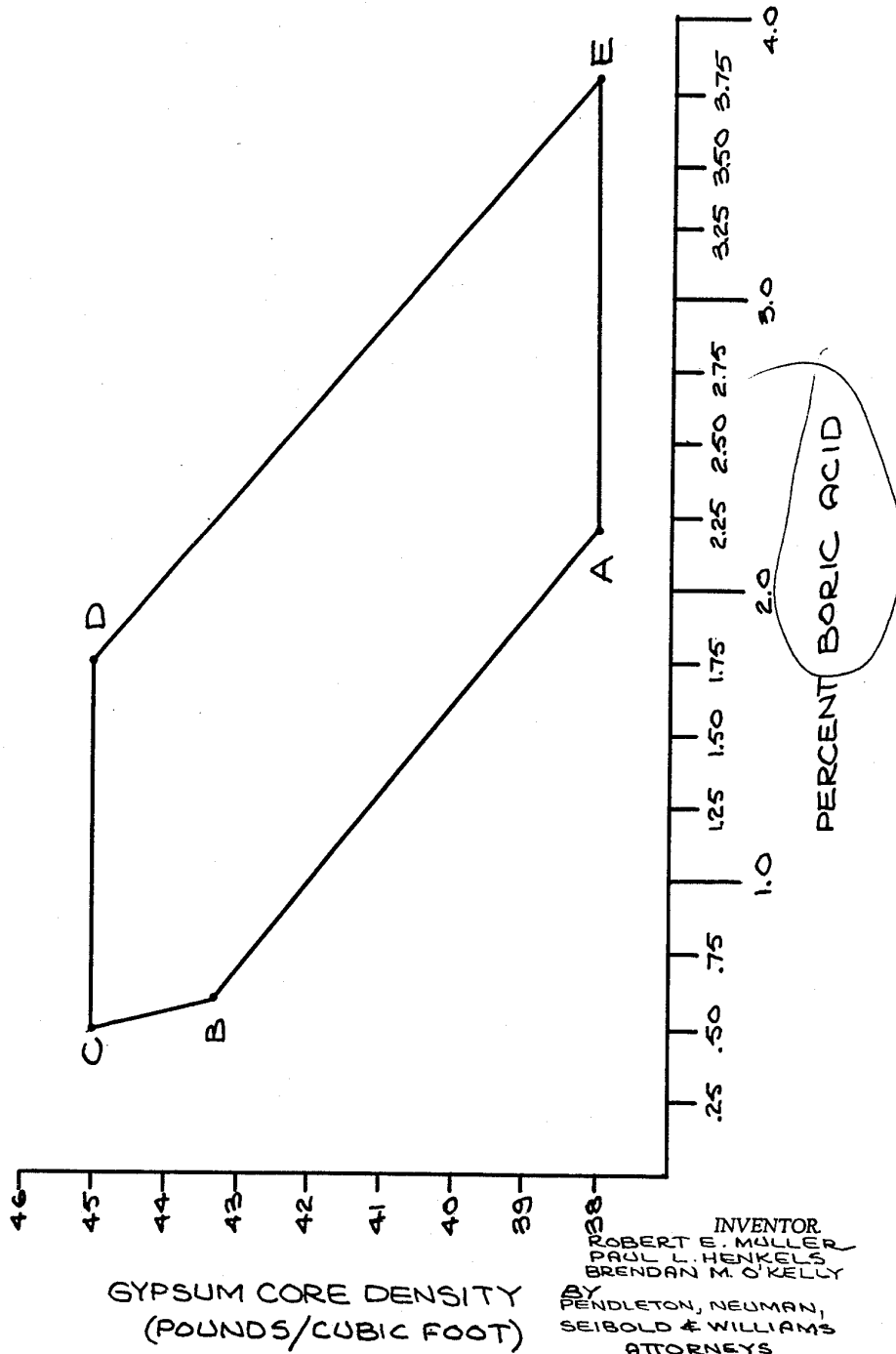
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3,190,787

GYPSUM BOARD

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1

3,190,787 GYPSUM BOARD

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This invention relates to improved gypsum board products, and more particularly to low density or light weight boric acid modified gypsum boards having improved properties.

Gypsum board products, comprising a monolithic core of set gypsum and a paper cover sheet encasement, are well known in the art. They are widely used in the construction of interior walls and ceilings, and are variously termed gypsum board, plaster-board, or the like. To reduce the weight of these products it has been conventional to introduce foam into the slurry of calcium sulfate hemihydrate (or gypsum stucco) and water during the board forming process. This produced a building or gypsum board product having a cellular, set gypsum core with a lower density than was formerly obtained. This concept is disclosed in Roos Patents Nos. 2,017,022, dated October 8, 1935, and 2,080,009, dated May 11, 1937. While there are obvious advantages in increasing the amount of foam in the gypsum core material to make a lighter product and thereby reduce shipping costs and increase handle-ability, there are certain drawbacks which militate against such an expedient. For example, it has been found that additionally decreasing the density of the gypsum core by the addition of foam to make a lower density core or light weight gypsum board product, results in certain drawbacks, such as a general decrease in strength and a considerable increase in bond failure. The term "bond" refers to the bond between the paper cover sheet and the gypsum core. Since the paper sheet constitutes the finish surface of a wall or ceiling, separation or looseness to any substantial degree results in a completely unsatisfactory product.

Any decrease in strength would likewise be a cause for lack of consumer acceptance. Accordingly, the conventional weight of one-half inch gypsum board with acceptable field performance has necessarily run about 2050 pounds per thousand square feet. This product has a gypsum core density of about 49.8 pounds per cubic foot.

Boric acid has been used in small amounts as an additive in some of these conventional weight or "high density" gypsum board products to eliminate sagging. The amount of boric acid used was small, however, not exceeding about 0.3% by weight of the set core. It was found however that increasing the boric acid content of these conventional weight boards resulted in harmful side effects. For example, experiments demonstrated that an increase to 0.38% boric acid in one-half inch gypsum boards, having a weight of 2000 to 2050 pounds per thousand square feet (#/M s.f.) or a core density of 48.5 to 49.8 pounds per cubic foot, resulted in embrittlement of the board to the extent that 5% to 10% of the boards cracked in the board handling equipment. Increase in boric acid to about 0.5% at this density caused a further increase in breakage to 20%. Increasing the percentage of boric acid to 0.82% resulted in 35% cracking.

From the foregoing it is apparent that it would be desirable to produce a commercially acceptable light weight gypsum board product that would have the advantage of ease of handling and reduced shipping costs, but without sacrifice of strength or paper to core bond.

Accordingly, one of the objects of this invention is the production of a light weight gypsum board having ac-

2

ceptable performance properties, particularly with respect to strength and bond properties.

A further object is the provision of a gypsum board having acceptable performance properties and reduced shipping costs.

A still further object is the provision of an improved gypsum board product without any substantial increase in embrittlement.

These and other objects will appear from the following description, drawing and appended claims.

Referring to the accompanying drawing, there is illustrated a graphical plot of gypsum core density in pounds per cubic foot against percent boric acid in the core material.

It has been found that the area defined by the straight lines connecting the points A, B, C, D and E of the drawing represents the permissible variation in boric acid content of low density gypsum cores to attain the objects of this invention in the production of improved light weight gypsum boards.

Accordingly, in one broad form of the present invention there is provided a light weight gypsum board, comprising a monolithic core of a boric acid modified set gypsum and a paper cover sheet encasement, said gypsum core having a density of from 38 to 45 pounds per cubic foot, and containing boric acid in an amount falling within the area defined by the accompanying drawing and further identified by the fact that said area is within the straight lines connecting the points A, B, C, D and E on said drawing.

In the most preferred form, the present invention is directed to an improved light weight gypsum board comprising a monolithic core of a boric acid modified set gypsum and a paper cover sheet encasement, said gypsum core having a density of from 38 to 43.5 pounds per cubic foot, and containing boric acid in a minimum amount, as determined by the formula

$$B = 0.6 + \frac{43.5 - D}{3}$$

wherein B is the percent boric acid, and D is the density of the gypsum core. The percentage of boric acid referred to above is on a weight basis with reference to the set core, containing ordinarily on the average about 1% free moisture.

As previously pointed out, the addition of boric acid in large amounts causes embrittlement. In the preferred form the upper limit of boric acid that can be utilized without undue embrittlement in low density gypsum boards is determined by the formula

$$B' = 2.0 + \frac{43.5 - D}{3.2}$$

where B' is the percent boric acid in the core material (dry basis) and D is the core density as previously defined, within the preferred range noted.

It can be appreciated that the formulation of gypsum board products in accordance with this invention involves the conventional additives of foams, set accelerators, bonding agents, retarders, etc., all of which are well known in this art.

The gypsum board products of this invention may be prepared in a variety of thicknesses which are commonly used in the industry, ranging from 1/4 inch to 3/4 inch thicknesses. Likewise the gypsum board may be provided in suitable sizes and various types of paper cover sheets.

For a more complete understanding of this invention reference is made to the following specific examples.

EXAMPLE 1.—1800 POUND BOARD (1/2 INCH)

The following formulation is used in the continuous

3

manufacture of ½ inch gypsum board. The amounts of the ingredients are given in terms of pounds per 1000 square feet of finished board. The boric acid is in terms of percent by weight of the dry core of the finished board.

	lbs./M s.f.
Finished dry board weight	1800
Gypsum stucco (hemihydrate)	1360
Paper fiber	21.8
Accelerator	6.5
Lignin dispersant	3.4
Starch	8.3
Foaming agent (rosin soap—60% solids)	.95–1.2
Foam water	278
Gauging water	901
Boric acid	Variable

Gypsum boards using conventional paper cover sheets were prepared using the above formulation and varying amounts of boric acid. The following results were obtained:

Table I

Board weight: 1,800 pounds per thousand square feet
Core density: 43.3 pounds per cubic foot

Percent boric acid	Percent bond failure (avg.)	Field split, inches (average face and back)
0	27.6	38/16
.2	31.2	66/16
.3	22.5	24/16
.5	19.5	0
.6	6.0	0
.9	5.1	0
1.3	4.9	0

It is desirable, when the facing paper is peeled away from the gypsum core of finished board, for no failure to occur at the paper-core interface or within the gypsum core next to the paper. "Bond failure" is the percent of area where failure occurs at the interface (designated as clean peel) or within the core (designated as split). Bond failure must be less than 10 percent to produce a commercially acceptable product. The test is performed after conditioning at 90% relative humidity and 90° F. for 24 hours.

"Field split" is the average length of a core split or core delamination in the field (central area) of the board. The boards are conditioned at 77° F. at 50% relative humidity for 24 hours prior to testing. A maximum of ⅛ inch is required to meet commercial requirements.

"End split" is the average length of core split or core delamination at the butt ends of the board. The boards are conditioned at 90° F. and 90% relative humidity for 24 hours prior to testing. To meet commercial requirements, failure cannot exceed ⅛ inch.

From the above data it will be noted that satisfactory bond failure properties are achieved when the amount of boric acid is about 0.6%, resulting in bond failure of 6.0%. Without boric acid, bond failures were of the order of 27%.

EXAMPLE II.—1700 POUND BOARD (½ INCH)

This example followed the procedure of Example I but the ingredients were adjusted to produce 1700 pounds per thousand square feet gypsum board.

	lbs./M s.f.
Finished board weight	1700
Gypsum stucco (hemihydrate)	1270
Paper fiber	21.8
Accelerator	8.3
Lignin dispersant	3.9
Starch	8.6
Foaming agent (rosin soap—60% solids)	1.4–1.6
Foam water	270
Gauging water	811
Boric acid	Variable

4

Gypsum boards, with conventional paper cover sheet encasements, were prepared with variable boric acid content from the above formulation. The following results were obtained:

Table II

Board weight: 1,700 pounds per thousand square feet
Core density: 40.7 pounds per cubic foot

Percent boric acid	Percent bond failure (avg.)	Field split, inches (average face and back)	End split, inches (average face and back)
0	40.7	11/16	15/16
.7	39.3	7/16	7/16
.8	16.9	9/16	3/16
1.3	15.2	5/16	3/16
1.7	1.3	2/16	3/16

EXAMPLE III.—1625 POUND BOARD (½ INCH)

Gypsum boards were prepared following the procedure of Examples I and II using the following formulation. Results are reported in Table III below, showing variation in properties with boric acid content:

	lbs./M s.f.
Finished board weight	1625
Gypsum stucco (hemihydrate)	1200
Paper fiber	21.8
Accelerator	8.3
Lignin dispersant	3.9
Starch	8.6
Foaming agent (rosin soap—60% solids)	1.55–1.65
Foam water	270
Gauging water	787
Boric acid	Variable

Table III

Board Weight: 1625 pounds per thousand square feet
Core density: 38.7 pounds per cubic foot

Percent boric acid	Percent bond failure (avg.)	Field split, inches (average face and back)	End split, inches (average face and back)
0	48	26/16	14/16
1.4	58	8/16	6/16
1.7	40	7/16	3/16
2.1	37	7/16	4/16
2.4	2.4	8/16	1/16

From the foregoing examples it may be observed that the addition of boric acid has a substantial and beneficial result in low core density, light weight gypsum boards. In addition to producing excellent bond between the cover sheet and gypsum core, the gypsum board products of this invention have excellent nailing properties. While the specific examples are directed to ½ inch boards, it will be understood that the teachings of this invention are broadly applicable to other board thicknesses.

As previously pointed out with reference to the drawing annexed hereto, the area defined by the straight lines interconnecting the points A, B, C, D and E, in that order represents the broad operable limits of boric acid related to the gypsum core density of the finished board. The upper limit beyond which undue embrittlement and consequent breakage of the boards occurs is represented by the line D–E. For convenience in defining the total area, the coordinates of each point A, B, C, D and E in terms of boric acid content on a graphic plot of core density against boric acid content are given below:

Point	Core density (lbs./cu. ft.)	Boric acid (percent)
A	38.0	2.2
B	43.3	.6
C	45.0	.5
D	45.0	1.8
E	38.0	3.8

It should also be understood that this invention is

5

also directed to the method, as disclosed above, for producing an improved light weight gypsum board by the incorporation therein of boric acid in the amounts above determined, as described in the foregoing specification.

While several particular embodiments of this invention are shown above, it will be understood that the invention is not to be limited thereto, since many modifications may be made, and it is contemplated therefore, by the appended claims, to cover any such modifications as fall within the true spirit and scope of this invention.

We claim:

1. A light weight gypsum board consisting essentially of a monolithic cellular core of boric acid modified set gypsum and a paper cover sheet encasement, said cellular gypsum core having a density of from 38 to 45 pounds per cubic foot and containing boric acid in an amount falling within the area defined by the straight lines connecting the points A, B, C, D and E, wherein said points are located on a rectangular Cartesian coordinate plot of core density in pounds per cubic foot and percent by weight of boric acid in said core, said points being located by the following coordinates:

Point	Core density	Boric acid
A-----	38.0	2.2
B-----	43.3	.6
C-----	45.0	.5
D-----	45.0	1.8
E-----	38.0	3.8

2. A light weight gypsum board consisting essentially of a monolithic cellular core of a boric acid modified set gypsum and a paper cover sheet encasement, said cellular gypsum core having a density of from 38 to 43.5 pounds per cubic foot, and containing boric acid in an amount determined by the formulas

$$B = 0.6 + \frac{43.5 - D}{3}$$

and

$$B' = 2.0 + \frac{43.5 - D}{3.2}$$

wherein B and B' are, respectively, the lower and upper values of the boric acid content in percent by weight, and D is the density of the gypsum core in pounds per cubic foot.

3. A light weight gypsum board consisting essentially of a monolithic cellular core of a boric acid modified set gypsum and a paper cover sheet encasement, said cellular gypsum core having a density of from about 38 to about 43.5 pounds per cubic foot, and containing boric acid in an amount of from 0.6 to 2.0 percent by weight at the higher density, and from 2.4 to 3.7 percent by weight at the lower density, the intermediate values being adjusted on a proportionate basis.

4. A light weight gypsum board consisting essentially of a monolithic cellular core of a boric acid modified set gypsum and a paper cover sheet encasement, said cellular gypsum core having a density of about 38.7 pounds per cubic foot and containing boric acid in an amount of from 2.4 to 3.7 percent by weight.

5. A light weight gypsum board consisting essentially of a monolithic cellular core of a boric acid modified set gypsum and a paper cover sheet encasement, said cellular gypsum core having a density of about 40.7 pounds per cubic foot and containing boric acid in an amount of from 1.5 to 2.9 percent by weight.

6. A light weight gypsum board consisting essentially of a monolithic cellular core of a boric acid modified set

6

gypsum and a paper cover sheet encasement, said cellular gypsum core having a density of about 43.3 pounds per cubic foot and containing boric acid in an amount of 0.7 to 2 percent by weight.

7. In a light weight gypsum board consisting essentially of a monolithic cellular core of set gypsum and a paper cover sheet encasement the improvement which comprises providing a cellular gypsum core having a density of from 38 to 43.5 pounds per cubic foot and containing boric acid in an amount determined by the formulas

$$B = 0.6 + \frac{43.5 - D}{3}$$

and

$$B' = 2.0 + \frac{43.5 - D}{3.2}$$

wherein B and B' are, respectively, the lower and upper limits of boric acid content in percent, and wherein D is the density of the gypsum core in pounds per cubic foot.

8. A method of producing lightweight paper covered gypsum board having a set core of cellular gypsum and improved paper to core bond properties which comprises the steps of preparing a slurry of calcined gypsum and boric acid in water, reducing the density of the slurry by the addition of foam, depositing the slurry of reduced density between paper cover sheets, forming the slurry and paper cover sheets into a board having a cellular core of set gypsum and drying the board, the dried cellular core having a density of from 38 to 45 pounds per cubic foot and a percentage of boric acid on a dry set gypsum core basis such as to fall within the area defined by the straight lines connecting the points A, B, C, D and E, in that order, in the accompanying drawing.

9. A method of producing lightweight paper covered gypsum board having a set core of cellular gypsum and improved paper to core bond properties which comprises the steps of preparing a slurry of calcined gypsum and boric acid in water, reducing the density of the slurry by the addition of foam, depositing the slurry of reduced density between paper cover sheets, forming the slurry and paper cover sheets into a board having a cellular core of set gypsum, and drying the board, the dried cellular core having a density of from 38 to 45 pounds per cubic foot and a percentage of boric acid on a dry set gypsum core basis within the range defined by the formulas

$$B = 0.6 + \frac{43.5 - D}{3}$$

and

$$B' = 2.0 + \frac{43.5 - D}{3.2}$$

wherein B and B', respectively, are upper and lower limits in percent by weight of boric acid in the core and D is the density of the core in pounds per cubic foot.

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