MANUAL OF
Membrane Fireproofing
for Gypsum Lath & Plaster Assemblies

GYPSUM ASSOCIATION 201 N. Wells Street • Chicago 6, Illinois
Gypsum lath and plaster is lightweight fireproofing that is interposed between a possible source of fire and the structural steel of the building—any steel frame building. It is commonly referred to as membrane fireproofing as opposed to individual encasement of structural members with concrete or masonry. Serving a multiple purpose, it provides both the necessary fire protection to prevent structural failure and the spread of fire, plus the interior finish for a building.

The use of membrane fireproofing is recognized, and appropriate fire resistance ratings have been accepted by most building codes. The essential elements as described herein are:

1. Gypsum lath and plaster ceilings.
2. Gypsum lath and plaster perimeter encasement of steel columns.
3. Hollow steel stud and solid gypsum lath and plaster partitions.

Combined, these elements provide systems for fire protection of the structural steel framing of any building, and the necessary subdividing partitions.

FUNCTIONAL VALUES

Fireproof — Gypsum lath and plaster is incombustible — will not burn or transmit excessive temperatures until the gypsum
Membrane Fireproofing

has completely calcined (all the water of crystallization driven off). Fortunately, this is a slow process.

Permanence—Gypsum is a mineral, apparently unaffected by time. It has been used in home building in the U. S. for more than 70 years.

Dead Load Reduction—Membrane fireproofing reduces the dead load weight of a building by as much as 50%, thus saving at least 15% of the structural steel usually required to carry a heavier building. Longer spans are generally possible, thus requiring fewer columns. A saving of as much as $\frac{1}{3}$ can be expected in footings and foundations.

Costs—A steel frame structure with lath and plaster fireproofing is generally competitive with reinforced concrete and very often lower in cost—even for structures of 8 stories or less. According to cost figures from projects in three different cities, steel frame construction with membrane fireproofing saves from 29¢ to 92¢ per square foot of floor area in comparison with reinforced concrete.

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>FRAME COST (PSF)</th>
<th>STEEL FRAME SAVINGS (PSF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEMBRANE FIREPROOFED STEEL</td>
<td>REINFORCED CONCRETE</td>
<td>DOLLARS</td>
</tr>
<tr>
<td>Typical 12 story office building, Chicago</td>
<td>$2.73</td>
<td>$3.65</td>
</tr>
<tr>
<td>Forty 8 story apartment buildings, New York City</td>
<td>2.50</td>
<td>2.79</td>
</tr>
<tr>
<td>A two story hospital building, Long Island</td>
<td>2.59</td>
<td>2.95</td>
</tr>
<tr>
<td>A 12 story apartment building, New York City</td>
<td>2.34</td>
<td>3.21</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>$2.34</td>
<td>$3.15</td>
</tr>
</tbody>
</table>

Another example is 3 high-rise apartment buildings for the East St. Louis PHA. Low bid for the steel frame-lath and plaster design was 99¢ per square foot less than the low bid in reinforced concrete. Savings of $5\frac{1}{2}$ percent of the total building cost were realized.

Mechanical Equipment—Space between the floor slab and fireproof ceiling may be used to house mechanical equipment. See Design Data.
Membrane fireproofing for lightweight fire resistive ceilings consists of gypsum lath and plaster, attached to or suspended from the steel beams or joists that normally carry a concrete floor or roof slab. The plaster thickness, type and reinforcement are the principal determinants for fire resistance. Sand may be used as the plaster aggregate for fire resistance ratings up to two hours, and perlite or vermiculite for ratings up to four hours.

With the steel floor beams and the concrete slab in place, ¾" furring channels are attached or suspended from the bottom chords of the supporting steel. They are placed 12" or 16" on centers depending upon the fire resistance required. Perforated gypsum lath, ¾" thick is attached to the furring by means of interlocking steel wire clips. One end engages the furring channel and the other end engages with the preceding clip. End joints are staggered with respect to adjacent courses of lath and occur at random between the furting channels. End joints of lath are clipped to adjacent courses by another clip as shown.

For greater fire resistance ratings a 14 gauge wire is inserted between lath and wire clip... diagonally across the lath face. When 4 hour fire resistance rating is desired, 20 gauge galvanized 1" hexagonal wire mesh is wire-tied beneath gypsum lath.

Interlocking wire clips are readily attached over furring members to support gypsum lath plaster base. Note edge clip ready for next section of lath.

Next step is to spray plaster on ceiling lath-and-clip assembly. Membrane fireproofing ceiling is completed with a thin plaster white coat.
Examples of the various types of edge clips and interlocking wire clips that are used in ceiling assemblies.

The plaster basecoat may be gypsum neat cement plaster (hardwall) either job mixed with aggregates or mill prepared lightweight aggregate plasters. Aggregates may be sand, perlite or vermiculite complying with ASTM designation C-35. The thickness and proportioning should be in accordance with the construction as tested for each specific fire resistance rating as shown in the appendix. All three aggregates are acceptable for fire resistance ratings up to and including 2 hours. For greater fire resistance lightweight aggregates must be used. Most building code and fire insurance rating authorities recognize the equivalence of perlite and vermiculite aggregates for fire resistance ratings. Thus their use is generally interchangeable.

Membrane fireproofed ceilings may be attached or suspended. If attached, the \( \frac{3}{4} \)" channels are clipped or tie-wired to the bottom chord of floor beams spaced not more than 4 feet on centers. If the ceiling is suspended, the hangers, runners and furring channels should be designed in strict accordance with American Standards Association Specification A42.4 from which the following tables have been taken, unless otherwise stated in the appendix.

For specific information on membrane fireproofing relative to beams, girders and trusses, fire stopping, and ceiling openings, refer to Design Data, page 8.
Exterior Wall Furring

Exterior wall furring consists of 3/8" or 1/2" thick long length gypsum lath, 24" wide held in floor and ceiling runners and plastered on the room face only with 1/2" thickness of plaster. At intermediate points of height, the lath is secured to horizontal furring channels by clips or wire ties, the channels in turn being secured to the masonry with wall anchors. The horizontal furring channels are spaced not more than 36" o.c. vertically, and are secured to the exterior wall or structural frame.

Membrane fireproofing of steel columns consists of wrapping 3/8" perforated gypsum lath around the perimeter of the column and plastering to whatever thickness is required for the specific fire resistance rating demanded by the building code or fire insurance rating bureau.

The gypsum lath is held in place with double strands of tie-wire around the lath and spaced vertically about 16" on centers. Corner beads are applied in the usual manner by staples or tie-wire and positioned to provide grounds for the predetermined plaster thickness. Sanded plaster may be used for fire resistance ratings up to three hours and lightweight aggregates for ratings up to four hours. (See Appendix on Fire Resistance Ratings).
LIGHT WEIGHT PARTITIONS

Lightweight fire resistive partitions are appropriate in lieu of heavy masonry to attain the maximum economy in design. Although any partition may be used in a steel frame building, lath and plaster partitions reduce by at least 50% the usual dead load weight of masonry partitions which weigh between 30 and 50 pounds per square foot.

SOLID GYPSUM LATH AND PLASTER

Solid gypsum lath and plaster partitions consist of ½" thick long length gypsum lath, (floor-ceiling length) 24" wide, plastered on both sides to a total of not less than 2". The lath extends in a continuous sheet from floor to ceiling and is secured at top and bottom to special runners. No studs are required. When used with metal floor and ceiling runners, solid studless partitions are incombustible and are accepted by building codes for as much as two hour fire resistance. They conserve ½ to ¾ of the floor area required by masonry partitions, thus providing up to 6% additional useable space.

Two inch solid gypsum lath and plaster partitions have qualified under the usual building code requirements for structural strength.
These partitions consist of steel studs with "open webs" surfaced on both sides with gypsum lath and plaster to form a complete, yet hollow assembly. Available normally in widths from 1 1/2" to 6", steel studs are particularly appropriate for walls containing plumbing, electrical or other services. Studs are secured in appropriate floor and ceiling runners and gypsum lath is then attached by use of special steel clips, or transverse wire clips as described for ceilings. End joints of lath are staggered in alternate courses and occur at random with respect to the studs. Lath ends are secured at corners as shown.

Hollow steel stud partitions using perforated gypsum lath and 1/2" gypsum plaster on both sides have qualified for fire resistance ratings up to 1 1/2 hours. (See appendix on Fire Resistance Ratings.)
DESIGN DATA & RECOMMENDATIONS

Beams, Girders and Trusses

Most building codes and fire insurance rating regulations allow beams, girders and trusses (which support loads from only one floor or roof with ceiling) to be membrane fireproofed, providing it supplies the protection required. If the bottom of a beam, girder or truss projects below the surface of the ceiling, furring is carried down and around the lower flange.

When beams, girders or trusses support masonry or reinforced concrete walls or loads for more than one floor or roof it is usually required that they be individually protected. This is normally done with self-furring metal lath and gypsum plaster. The protection required is often greater than the fire resistance rating required for the adjacent floor-ceiling.

Fire Stopping

Many building codes and fire insurance rating regulations require that the plenum space between fire resistive ceilings and non-combustible floors be fire stopped. This is done by dividing the plenum space into areas ranging from 1500 feet up using 24 gage steel as a minimum fire stop. If beams or girders have solid webs and if ceiling fireproofing is in contact with the lower flange of these structural members, they can serve as acceptable fire stops themselves, providing the plenum area between such members does not exceed code requirements.

Ceiling Openings

Numerous tests have been conducted to determine the effects on fire resistance caused by openings in ceilings to accommodate duct and electrical outlets.

Tests on ceilings of gypsum plaster show that such openings have little or no effect on the fire resistance providing the aggregate area of the openings does not exceed 100 sq. in. per 100 sq. ft. of ceiling area.

Duct openings should be equipped with a 14 gage steel damper having a 160° fusible link. The area of electrical outlets should not exceed 16 sq. in. per outlet.

Most building codes permit ceiling openings as herein described.

Design Weights

Gypsum lath—3/8" and 1/2" thick, 1 1/2 and 2 pounds per square foot respectively.
Sanded Plaster—8 pounds per square foot per inch of thickness.
Lightweight Aggregate Plaster—4 pounds per square foot per inch of thickness.

Two Inch Solid Partition:
Sanded Plaster—14 lbs./sq. ft.
Lightweight Plaster—8 lbs./sq. ft.

Hollow Steel Stud Partitions with Gypsum Lath:
Sanded Plaster—14 lbs./sq. ft.
Lightweight Plaster—10 lbs./sq. ft.

Maximum Heights

Two Inch Solid Partition—12 feet.
Hollow Steel Stud Partition—Up to 35 feet. (See manufacturers directions).

Sound Transmission Loss

There follows a listing of the average sound transmission loss ratings in decibels as recorded in BMS Report No. 144 published by the U. S. Department of Commerce, National Bureau of Standards. The average values are for a range of frequencies from 128 to 4,096 cycles per second.

Two inch solid gypsum lath and sanded plaster partitions .............................................. 37 db.
Two inch solid gypsum lath and perlite plaster partitions .............................................. 34-35 db.
Hollow steel stud with gypsum lath and sanded plaster partitions ...................................... 43-46 db.
Hollow steel stud with gypsum lath and (perlite) plaster .................................................... 38-40 db.
3" hollow clay tile, 1/2" thick plaster both sides 40-42 db.
Steel joist floor assembly, 2 1/2" concrete floor slab, lath and plaster ceiling ....................... 55 db.
Tapping loss for above construction .......................... 13 db.
4" concrete floor slab ........................................... 47 db.
Tapping loss for above ........................................ 2 db.

Use of Plenum Space

If the plenum space formed by floor slab and ceiling is used to supply or exhaust conditioned air, without ducts, the design must prevent possible condensation within the plenum space; and the air temperature should not exceed 125° F.

Lateral Rigidity

Although membrane fireproofing has some lateral rigidity, it should not be considered. The structural frame for buildings should be designed for load, wind and seismic resistance irrespective of this factor.

The fire test standards of the American Society for Testing Materials are the basis for test procedures used by nationally recognized laboratories such as those at the National Bureau of Standards, Ohio State University and Underwriters' Laboratories, Inc. The fire resistive ratings indicated on the following pages are the results of tests conducted in accordance with the requirements of ASTM-E119, which is the fire test standard used by all building codes.
FLOOR-CEILING ASSEMBLY

3/8" Perforated Gypsum Lath
Steel Joists
2" Concrete Floor

<table>
<thead>
<tr>
<th>Fire Resistance Rating, Hours</th>
<th>Test No.</th>
<th>Gypsum Plaster Thickness</th>
<th>Aggregate &amp; Proportions</th>
<th>Special Construction Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>#287 NBS</td>
<td>3/8&quot;</td>
<td>Perlite or Vermiculite 1:2 1/2</td>
<td>16&quot; channel spacing</td>
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<td></td>
<td>1-17-51</td>
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<td></td>
<td>#3657-5 U.L.</td>
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<tr>
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<td>3-20-56</td>
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</tr>
<tr>
<td>1 1/2</td>
<td>#295 NBS</td>
<td>1&quot;</td>
<td>Perlite or Vermiculite 1:2-1:3</td>
<td>16&quot; channel spacing</td>
</tr>
<tr>
<td></td>
<td>3-15-51</td>
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</tbody>
</table>
FLOOR-CEILING ASSEMBLY

3/8" Perforated Gypsum Lath
Diagonal Wire
Steel Joists
2" Concrete Floor

<table>
<thead>
<tr>
<th>Fire Resistance Rating, Hours</th>
<th>Test No.</th>
<th>Gypsum Plaster Thickness</th>
<th>Aggregate &amp; Proportions</th>
<th>Special Construction Notes</th>
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<td>2</td>
<td>#345</td>
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<td>Sand 1:2:1:3</td>
<td>12&quot; channel spacing</td>
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<td>NBS 9-23-54</td>
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<td>2 1/2</td>
<td>#318</td>
<td>1/2&quot;</td>
<td>Perlite or Vermiculite 1:2 1/2</td>
<td>16&quot; channel spacing</td>
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<td></td>
<td>NBS 11-25-52</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>#313</td>
<td>5/8&quot;</td>
<td>Perlite or Vermiculite 1:2:1:3</td>
<td>12&quot; channel spacing</td>
</tr>
<tr>
<td></td>
<td>NBS 4-24-52</td>
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</table>
## Floor-Ceiling Assembly

**Materials:**
- 1/8" Perforated Gypsum Lath
- Wire Mesh
- Steel Joists
- 2" Concrete Floor

**Diagram:**
- 1/4" Furring Channel
- 1/8" Thick Perforated Gypsum Lath
- Interlocking Steel Wire Clips Attached to Furring Channel
- Edge or Joint Clips
- Scratch Coat
- Brown Coat
- Pouréd Concrete

### Fire Resistance Rating

<table>
<thead>
<tr>
<th>Fire Resistance Rating, Hours</th>
<th>Test No.</th>
<th>Gypsum Plaster Thickness</th>
<th>Aggregate &amp; Proportions</th>
<th>Special Construction Notes</th>
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<tbody>
<tr>
<td>3</td>
<td>#312</td>
<td>1/2&quot;</td>
<td>Perlite or Vermiculite 1:2 5/2</td>
<td>16&quot; channel spacing 1&quot; mesh, 20 gage wire</td>
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<tr>
<td></td>
<td>NBS</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2-14-52</td>
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<tr>
<td>4</td>
<td>#311</td>
<td>1&quot;</td>
<td>Perlite or Vermiculite 1:2-1:3</td>
<td>12&quot; channel spacing 1&quot; mesh, 20 gage wire</td>
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<td></td>
<td>NBS</td>
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<td>12-7-51</td>
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FLOOR-CEILING & BEAM ASSEMBLY

3/8" Gypsum Lath and Metal Lath
Cellular Steel
Suspended Ceiling
Concrete Floor

<table>
<thead>
<tr>
<th>Fire Resistance Rating, Hours</th>
<th>Test No. Auth. &amp; Date</th>
<th>Gypsum Plaster Thickness</th>
<th>Aggregate &amp; Proportions</th>
<th>Special Construction Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>#337 NBS 1-6-54</td>
<td>1/2&quot; on ceiling</td>
<td>Perlite or Vermiculite 1:2½</td>
<td>Deck: 2½&quot; concrete. Ceiling: gypsum lath, 12&quot; channel spacing, 14 ga. wire reinforcing. Beam: lath furred 2½&quot; below.</td>
</tr>
<tr>
<td>4</td>
<td>#3574 U.L. 4-15-57</td>
<td>3/4&quot;</td>
<td>Perlite or Vermiculite 1:2-1:2</td>
<td>Beam: 4 hours; Ceiling: 3 hours. Deck: 2&quot; concrete. Ceiling: includes metal ventilating duct and opening with non-combustible fire damper; metal lath suspended 3½&quot; below beams, 12&quot; channel spacing.</td>
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</table>
## STEEL COLUMN ASSEMBLY

### 3/8" Perforated Gypsum Lath

### Special Construction Notes

<table>
<thead>
<tr>
<th>Fire Resistance Rating, Hours</th>
<th>Test No. Auth. &amp; Date</th>
<th>Gypsum Plaster Thickness</th>
<th>Aggregate &amp; Proportions</th>
<th>Special Construction Notes</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>#273 NBS 9-18-50</td>
<td>1/2&quot;</td>
<td>Sand 1:2 1/2</td>
<td>Double strand of tie wire 15” O.C. Vertically</td>
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<tr>
<td>11/2</td>
<td>#274 NBS 9-20-50</td>
<td>5/8&quot;</td>
<td>Sand 1:2 1/2</td>
<td>Double strand of tie wire 15” O.C. Vertically</td>
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<tr>
<td>2</td>
<td>#351 NBS 3-11-55</td>
<td>1-3/8&quot;</td>
<td>Sand 1:2-1:3</td>
<td>Double strand of tie wire 15” O.C. Vertically</td>
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<tr>
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<td>#275 NBS 9-26-50</td>
<td>1&quot;</td>
<td>Perlite or Vermiculite 1:2 1/2</td>
<td>Double strand of tie wire 15” O.C. Vertically</td>
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<tr>
<td>3</td>
<td>#321 NBS 1-21-53</td>
<td>1-3/4&quot;</td>
<td>Perlite or Vermiculite 1:2-1:3</td>
<td>Double strand of tie wire 15” O.C. Vertically</td>
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<tr>
<td>3</td>
<td>#344 NBS 9-24-54</td>
<td>2&quot;</td>
<td>Sand 1:2-1:3</td>
<td>Double strand of tie wire 15” O.C. Vertically</td>
</tr>
</tbody>
</table>
## STEEL COLUMN ASSEMBLY

\( \frac{1}{2} \)" Plain Gypsum Lath — Wire Mesh

<table>
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<tr>
<th>Fire Resistance Rating, Hours</th>
<th>Test No.</th>
<th>Test No.</th>
<th>S NSF</th>
<th>Gypsum Plaster Thickness</th>
<th>Aggregate &amp; Proportions</th>
<th>Special Construction Notes</th>
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<tbody>
<tr>
<td>4</td>
<td>#278</td>
<td>NBS</td>
<td>10-3-50</td>
<td>1-( \frac{1}{2} )&quot;</td>
<td>Perlite 1:2:1.3</td>
<td>1&quot; mesh, 20 gage wire</td>
</tr>
<tr>
<td>4</td>
<td>#294</td>
<td>NBS</td>
<td>5-25-51</td>
<td>1-( \frac{1}{2} )&quot;</td>
<td>Vermiculite 1:2:1.3</td>
<td>1&quot; mesh, 20 gage wire</td>
</tr>
</tbody>
</table>

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### Diagram: Steel Column Assembly

- **Scratch Coat**
- **Brown Coat**
- **Finish Coat**
- **Steel Column**
- **Two Layers 1/2" Thick Gypsum Lath**
- **Tie Wire**
- **1" Mesh 20 GA. Wire**
- **Corner Bead**

### Special Construction Notes

- **#278**
  - NBS
  - 10-3-50
  - 1-\( \frac{1}{2} \)"
  - Perlite 1:2:1.3
  - 1" mesh, 20 gage wire

- **#294**
  - NBS
  - 5-25-51
  - 1-\( \frac{1}{2} \)"
  - Vermiculite 1:2:1.3
  - 1" mesh, 20 gage wire
SOLID PARTITION ASSEMBLY
(Non Load Bearing)

1/2" Plain Gypsum Lath

<table>
<thead>
<tr>
<th>Fire Resistance Rating, Hours</th>
<th>Test No. Auth. &amp; Date</th>
<th>Gypsum Plaster Thickness</th>
<th>Aggregate &amp; Proportions</th>
<th>Special Construction Notes</th>
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<tbody>
<tr>
<td>1</td>
<td>T-118-7 &amp; T-216</td>
<td>3/4&quot; each side</td>
<td>Sand 1:1-1.2</td>
<td>2&quot; partition thickness</td>
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<td></td>
<td>Ohio State 6-8-49</td>
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<tr>
<td>1½</td>
<td>#282 NBS 1-16-51</td>
<td>3/4&quot; each side</td>
<td>Perlite or Vermiculite 1:2-1:3</td>
<td>2&quot; partition thickness</td>
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<tr>
<td>2</td>
<td>#300 NBS 5-29-51</td>
<td>1&quot; each side</td>
<td>Perlite or Vermiculite 1:2-1:3</td>
<td>2 1/2&quot; partition thickness</td>
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</tbody>
</table>
HOLLOW PARTITION ASSEMBLY
(Non Load Bearing)

Steel Stud—
⅛” Perforated Gypsum Lath

<table>
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<th>Test No.</th>
<th>Gypsum Plaster Thickness</th>
<th>Aggregate % Proportions</th>
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<tbody>
<tr>
<td>1</td>
<td>T-118-55</td>
<td>½” each side</td>
<td>Perlite or Vermiculite 1:2½</td>
<td>16” stud spacing 4-¼” partition thickness.</td>
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<td>Ohio State 6-15-53</td>
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<tr>
<td>1½</td>
<td>T-347</td>
<td>½” each side</td>
<td>Sand 1:2</td>
<td>16” stud spacing 4-¼” partition thickness.</td>
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<tr>
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<td>Ohio State 1-13-55</td>
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GYPSUM ASSOCIATION

Barrett Division, Allied Chemical Corporation
Bestwall Gypsum Company
Blue Diamond Corporation
The Celotex Corporation
Fibreboard Paper Products Corporation
The Flintkote Company
Grand Rapids Plaster Company
Kaiser Gypsum Company, Inc.
National Gypsum Company
The Ruberoid Co.
Union Gypsum Company
United States Gypsum Company