How does gypsum board perform in a fire situation? The results of fire endurance tests are detailed in the following article.

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by Paul S. Quigg

All materials have characteristics which require an understanding by the user in order to fully utilize the material or to avoid problems that may occur in using it. As a case in point, let’s examine the dimensional characteristics of ½-inch gypsum board.

Like all materials, gypsum board
will increase in dimension as the temperature increases, and will decrease as the temperature decreases. This is known as the thermal coefficient of expansion which, for ½-inch SHEETROCK® gypsum board, is $8.45 \times 10^{-6}$ in./in./°F in the machine direction of the board (length), and $9.70 \times 10^{-6}$ in./in./°F in the cross-machine direction (width).

If one were to measure the width of a single piece of gypsum board conditioned at 85 degrees F., and then again at 70 degrees F., you would find the second measurement 0.007 inches shorter than the first. No big deal, you say. Perhaps not, if one were to consider only a four-foot width. However, when you construct a wall and make these four-foot widths continuous by taping the joints, then you have a board with a width equal to the length of your wall.

Similarly, the dimensions of some products are also affected by changes in the relative humidity. This material characteristic is known as the hygrometric coefficient of expansion. In the case of ½-inch gypsum board, this characteristic is $7.20 \times 10^{-6}$ in./in. per percent relative humidity (in./in./% RH). In going from 70 percent RH to 50 percent RH, one would note a reduction in the 4-foot width of about 0.007 inches. These effects act independently; therefore, if the temperature conditions were reduced by 15 degrees F., and the relative humidity reduced by 20 percent, each four-foot width of board would be reduced by 0.014 inches, or about 1/64 of an inch. Imagine, if you will, a long corridor wall of gypsum board attached to studs erected at a temperature of 85 degrees F., and a humidity of 70 percent RH. The wall is constructed in the conventional manner, joints taped and secured so as to prevent movement along the Wall.

Now imagine that same wall at 70 degrees F. and 50 percent RH. The wall will attempt to become shorter because of thermal and hygrometric movement, but the attachment system will prevent this from occurring. Then the gypsum board and taping system must have sufficient strength to prevent this movement or the wall will develop a crack. Alternatively, the anticipated movement could be accommodated by designing a detail which would permit the dimensional change to occur and yet not be read as a crack.

The United States Gypsum Company (USG), in recognizing this phenomenon, recommends that, on long runs of walls, control joints be installed at a frequency not to exceed 30 feet center-to-center. The USG Control Joint No. 093, made of alloyed zinc capable of both expanding and contracting, is specifically recommended. This control joint has been designed to accommodate the thermal and hygrometric movement anticipated in a 30 foot run, as well as providing the necessary corrosion resistance. Walls incorporating the USG 093 control joint have been in service for several years; subsequent inspections have verified the effectiveness of the product and the detail for its installation.

Recently, the question was asked, “How can the 093 control joint be installed in a fire rated wall and still maintain the fire rating?” Recent tests at the Graham Morgan Research Center provided answers to this question.

Fire endurance tests were conducted to evaluate four expansion joint details using the 093 control joint constructed in a 1-hour fire rated wall assembly, and four expansion joint details constructed in a 2-hour fire rated wall. The details shown in Figures 1-3 were tested to determine the thermal transmission through the joint, and the ability to contain the fire to the side of origin when exposed to the ASTM E119 time-temperature fire exposure.

As shown in Figures 1-3, the 093
Gypsum board will increase in dimension as the temperature increases.

Control joints on opposing walls were separated by:
1. Air,
2. Gypsum board,
3. Gypsum board and mineral wool, and

Temperature measuring devices (thermocouples) attached to the control joints and the wallboard on the unexposed surface were used in determining the time to failure of each joint detail. Each detail was instrumented with two thermocouples on the control joint and two on the wallboard surface. Time to failure was determined as the lesser time of a 325 degree F. rise at any point or a 250 degree F. rise in the average of the four thermocouples.

Tests of control joint details installed in a 1-hour fire-rated partition (X-inch Type X gypsum board screw-attached to each face of drywall metal stud) indicated that some material must be placed in the cavity between the opposing 093 control joints to attenuate the heat. The observation was further verified in the test conducted evaluating control joints installed in a 2-hour fire rated partition (two layers of 5/8-inch Type X gypsum board screw-attached to each face of drywall metal studs). Air alone is not adequate to insulate the non-fire side of the partition so as to permit it to qualify under the current fire test procedures. However,

### TABLE 1
TEST SUMMARY

<table>
<thead>
<tr>
<th>Detail No.</th>
<th>Detail Description</th>
<th>Control Joint Endurance Hours : Minute : Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USG 093 Control Joint Only</td>
<td>0:36:18</td>
</tr>
<tr>
<td>2</td>
<td>Control Joint/Gypsum Board/Mineral Wool</td>
<td>1:39:19</td>
</tr>
<tr>
<td>3</td>
<td>Control Joint/Gypsum Board</td>
<td>1:14:30</td>
</tr>
<tr>
<td>4</td>
<td>Control Joint/Mineral Wool</td>
<td>1:05:59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2:30:00 +</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2:30:00 +</td>
</tr>
</tbody>
</table>
gypsum board, mineral wool or combinations of these materials do provide sufficient thermal insulation to qualify these control joint details.

A summary of test results of this investigation is contained in Table 1 and Figures 2 and 3. Figure 1 is a perspective view of the USG No. 093 control joint. Figure 2 shows four separate details of the No. 093 control joint installed in a 1-hour fire rated partition and, further shows the fire endurance failure time of each of the four details. Figure 3 provides that same information for a 2-hour fire rated partition.

In summary, the test results show three details for installing a control joint in a 1-hour and a 2-hour fire rated partition which accommodates hygrometric and thermal movement while still maintaining the fire rating for which the partition qualifies.

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