Determination of the Cause of Drywall Buttons in Relation to Substrate and Adhesive Movement Due to Variation in Environmental Conditions.

Background:

Testing was conducted to determine the cause of formation of protrusions ("buttons") on drywall assemblies that occur after some installations. Drywall buttons have plagued certain installations since the use of gypsum-based sheet materials became common, starting in the early 1900s. Different theories have been set forth that pointed blame at the type of fastener (nails versus screws), moisture content of the wood, lightweight versus traditional drywall and type of adhesive used during assembly. Our testing was conducted looking at two different environmental conditions. We used a hot and humid environment (100°F/90% RH) to simulate exterior exposure of substrates before installation, which resulted in 18-20% moisture content in the wood studs. We then used a hot, low RH environment (9% RH) to simulate both hot, dry conditions and cold, dry conditions that dried the wood studs to 3-4% moisture content. The testing looked at contributions of movement from the wood studs, type of fastener, drywall and nine different adhesives, both water- and solvent-based, to determine relative movement of the drywall surface to the head of the fastener.

Executive Summary:

The cause of drywall button pops is a combination of adhesive shrinkage, drywall shrinkage, wood stud movement based on moisture content, type of fastener and the technique of setting the fastener. Testing showed that movement of 40 mil (40 thousandths of an inch) is required to form a button pop. Wood stud movement and adhesive shrinkage produced the greatest dimensional movement of the above tested substrates at 7-20 mil and 10-20 mil respectively. Neither adhesive shrinkage nor wood stud movement in relation to the fastener head is typically great enough to cause a drywall button pop on its own. A combination of both movements is responsible for producing the button.

A wall produced with a wood stud, at typical lumber yard or hot and humid building conditions (approximately 18% moisture content), and drywall installed and finished with drywall compound immediately after hanging can allow enough movement of the wood and adhesive greater than that required to produce a drywall button pop.

A USG white paper published in June of 2014 noted that water-based adhesives can cause drywall button pops where solvent-based adhesives show no buttons. Water-based adhesives add water to the drywall near the upper surface of the wood stud/drywall/fastener bond line, and increase the moisture content of the wood, with subsequent swelling of the wood stud. It is proposed that this is the probable cause of this difference. Solvent from solvent-based adhesives will not swell wood substrates. But as testing shows, both water-based and solvent-based adhesives shrink and pull the drywall toward the stud. The combination of wood swelling and shrinkage on drying plus the shrinkage of the adhesive is the probable cause of drywall button pops seen with water-based assemblies versus solvent-based assemblies.

Question and Answer:

Could the drywall button pops be caused by USG Lightweight Drywall?

Movement of the USG Lightweight Drywall calculated on average to be only 0.0072 inches (7.2 mil) and was not considered excessive in terms of other movement seen in shrinkage from the adhesive and changes in moisture content of the wood stud. In combination with this other movement, it might contribute to button pops but would not have enough movement to cause them on its own. Chemical analysis of standard drywall versus the lightweight drywall showed no differences in chemical composition. The differences seen were in

entrapment of larger air pockets in the lightweight drywall. Therefore, although we did not test this, we do not believe that standard versus lightweight drywall would be a large factor in drywall assembly movement.

Why do we see differences in water-based versus solvent-based adhesives in the development of drywall button pops?

Water-based adhesives can add water to the drywall and wood stud bond line, increasing the moisture content of the wood and resulting in swelling of the wood stud. Solvent from solvent-based adhesives will not swell wood substrates. But as noted above, both water-based and solvent-based adhesives shrink and pull the drywall toward the stud with similar movement. The combination of wood swelling and shrinkage on drying, plus the shrinkage of the adhesive, is the probable cause of buttons seen in water-based assemblies versus solvent-based assemblies.

Does the water-based adhesive pull the drywall to the stud when it dries?

Both water-based and solvent-based products pull the drywall to the stud as they shrink during drying.

The USG White Paper states as follows: "Immediately after the drywall was fastened in place, a feeler gauge was used to determine whether or not there was a measureable gap between each wood stud and the drywall. The measured gaps ranged from .050 to .070 inches. After the screw buttons formed, the adhesive gaps were unable to be measured due to the fact that the drywall had moved tight up against the wood stud. This clearly documented that the adhesive shrank." Why would the gap disappear?

Because there is still adhesive in the bond line, the gap disappearance must be due to movement of the wood swelling from moisture in the adhesive. The adhesive, as shown in testing, will shrink but will not go to zero depth; therefore, any reduction of the gap beyond shrinkage of the adhesive must be caused by wood movement filling the gap.

How much does a bead of water-based drywall adhesive swell the surface of wood when applied? Does that swelling increase/decrease when the bead is flattened as the drywall is pressed and screwed into the wood stud?

In this testing. we did not have the capability of measuring the surface moisture conditions of the wood stud after assembly with the water based adhesive. It was noted that after application of the water-based adhesive, the drywall paper became saturated with water, showing a darkening of the backing paper. The assumption would be that the water was also penetrating the wood stud in a similar manner and that wood will increase in dimension up to around 30% moisture content. After approximately 30% moisture content, the wood fibers have soaked up all the water they can, and any extra water will not create any further movement. The pressure exerted by the wood screws and drywall onto the wood stud would not be considered enough pressure to decrease this swelling phenomenon.

Can we provide an adhesive recommendation dependent upon the condition of lumber, type of screw, gypsum board, time of year during installation, market location, etc.?

From this study we can make the following recommendations to reduce the chances of creating drywall button pops:

- If wood framing members are high in moisture content, it is best to allow the structure to dry below 10% wood moisture content to reduce the amount of fastener movement once the lumber dries out, with low-humidity conditions typical in a cold winter or hot dry climate. Use a moisture meter to determine moisture content of the wood framing before drywall installation.

- If drywall is hung with high moisture lumber, it is recommended to delay finishing of the fastener locations until the lumber has dried below 10% moisture content.

- If delay of finishing is not possible, it is best to use a polyurethane-based adhesive to reduce the contribution of shrinkage due to a solvent- or water-based adhesive and to eliminate water absorption from water-based adhesives and subsequent movement of the wood stud surface.

- Use the shortest fastener recommended by the drywall manufacturer. The longer the length of the fastener, the greater the relative movement of the screw head to the wood stud surface.

- Install fasteners with a dimple that does not break the paper. Testing showed that a dimpled fastener will allow for more movement before showing a drywall button pop. Overdriving screws reduces allowable movement to as low as 24 mil.

- If using water-based adhesives, allow more time before finishing for the wood to absorb and equilibrate extra moisture from the adhesive and subsequent wood swelling.