White Paper

# Evaluating Jobsite Environmental Conditions

The ideal conditions for the installation, finishing and decorating of USG SHEETROCK® Brand Gypsum Panel and USG FIBEROCK® Brand Panel systems are those that closely match the intended occupancy environment. This level of temperature, humidity, ventilation, and free moisture should be maintained continuously before stocking, during installation and after the completion of the finishing and decorating processes. Sharp swings in temperature, ventilation, and/or humidity, like those that occur when environmental control systems are turned off at night or on weekends, should be avoided. Rapid changes in environmental conditions cause thermal and hygrometric movement which is likely to cause cracking, bond loss or other problems.

USG does not offer or provide construction supervision or inspection services as it relates to the installation of our products or to evaluate jobsite environmental conditions. However, USG is available to assist its customers in understanding how USG products and systems should be applied or installed. This is accomplished through the review of USG product literature and USG system installation recommendations at the jobsite or an off-site location. If it's determined that inspection services are required by the owner, general contractor, or sub-contractor, then they should secure the services of an independent third party provider.

There are a number of industry standards for evaluating your current job conditions. Foremost among these is USG's Gypsum Construction Handbook. In addition, the Drywall Finishing Council (DWFC), Gypsum Association (GA), Association of the Wall and Ceiling Industry (AWCI), and the Painting and Decorating Contractors of America (PDCA), and Ceilings & Interior Systems Construction Association (CISCA) have a variety of papers and literature that discuss interior finishing problems associated with poor jobsite environmental conditions.

**Poor Job Conditions Create Movement**

Simply put, movement comes in three forms: thermal, hygrometric and structural.

– Thermal movement is created by the expansion or contraction of building materials with changes in temperature. All materials expand/contract by different amounts and rates as temperatures vary.

– Hygrometric movement is caused by the absorption or evaporation of water into or out of building materials. As with thermal movement, different materials absorb or release moisture at different rates as environmental conditions change. This function is greatly affected by the temperature and humidity of the space and the result is expansion/contraction as the moisture moves through the material.

– Structural movement is caused by dimensional changes and the physical shifting of building components. This form of movement is commonly associated with foundation settling or actual building movement due to wind or seismic forces. In high-rise construction, shortening of the columns occurs in the lower levels as the weight of the upper floors increases. The building structure also grows and shrinks as temperatures rise and fall with seasonal changes. Lumber shrinkage and changes in relative humidity in wood framed construction can cause physical movement, primarily in the cross-grain direction.

**Examples of Levels of Movement for Common Building Materials**

This movement, in whatever form it takes, is why USG recommends control joints and perimeter relief elements. The chart below illustrates the relative movement of some common building materials. The chart shows movement related to changes in both temperature and humidity of each material. It should be noted that the dimension changes due to variations in temperature and humidity are additive. For example, if the temperature movement of a material is .025" and the related humidity change causes .006" movement, the resulting movement is .031".

**Thermal Coefficients of Linear Expansion of Common Building Materials**

| 40 to 100 °F (4 to 38 °C), in./in./°F | | Change in length (in.) for 20° Δ in Temp for Material length (ft): | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | °F¹ | 10 | 20 | 50 | 80 | 90 | 100 | 120 |
| Gypsum Panels and Bases, Paper-Faced | 9.0E-06 | 0.022 | 0.043 | 0.108 | 0.173 | 0.194 | 0.216 | 0.259 |
| Gypsum Panels and Bases, Glass-Faced | 8.5E-06 | 0.020 | 0.041 | 0.102 | 0.163 | 0.184 | 0.204 | 0.245 |
| Gypsum Fiber-Reinforced Panels | 7.0E-06 | 0.017 | 0.034 | 0.084 | 0.134 | 0.151 | 0.168 | 0.202 |
| Gypsum Plaster, Sanded (100:2, 100:3) | 6.8E-06 | 0.016 | 0.033 | 0.082 | 0.131 | 0.147 | 0.163 | 0.196 |
| Gypsum Plaster, Wood Fiber (sanded 100:1) | 8.0E-06 | 0.019 | 0.038 | 0.096 | 0.154 | 0.173 | 0.192 | 0.230 |
| Gypsum Plaster, Perlited | 7.4E-06 | 0.018 | 0.036 | 0.089 | 0.142 | 0.160 | 0.178 | 0.213 |
| Gypsum Plaster, Vermiculite (sanded 100:2) | 8.6E-06 | 0.021 | 0.041 | 0.103 | 0.165 | 0.186 | 0.206 | 0.248 |
| Aluminum, Wrought | 1.3E-05 | 0.031 | 0.061 | 0.154 | 0.246 | 0.276 | 0.307 | 0.369 |
| Steel Framing, Typical (non-structural) | 6.7E-06 | 0.016 | 0.032 | 0.080 | 0.129 | 0.145 | 0.161 | 0.193 |
| Brick, Masonry | 3.1E-06 | 0.007 | 0.015 | 0.037 | 0.060 | 0.067 | 0.074 | 0.089 |
| Cement Board | 7.9E-06 | 0.019 | 0.038 | 0.095 | 0.152 | 0.171 | 0.190 | 0.228 |
| Cement, Portland | 5.9E-06 | 0.014 | 0.028 | 0.071 | 0.113 | 0.127 | 0.142 | 0.170 |
| Concrete | 7.9E-06 | 0.019 | 0.038 | 0.095 | 0.152 | 0.171 | 0.190 | 0.228 |
| Spruce Pine Fir (parallel to fiber) | 2.1E-06 | 0.005 | 0.010 | 0.025 | 0.040 | 0.045 | 0.050 | 0.060 |
| Spruce Pine Fir (perpendicular to fiber) | 3.2E-06 | 0.008 | 0.015 | 0.038 | 0.061 | 0.069 | 0.077 | 0.092 |

40 to 100 °F (in./in./°F)

**Hygrometric Coefficients of Expansion (Unrestrained)**

| Inches/Inch/% R.H. (5%—90% R.H.) | | Change in length (in) for 20% Δ RH in Temp for Material length (ft): | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Δ%RH⁻¹ | 10 | 20 | 50 | 80 | 90 | 100 | 120 |
| Gypsum Panels and Bases, Paper-Faced | 7.2E-06 | 0.017 | 0.035 | 0.086 | 0.138 | 0.156 | 0.173 | 0.207 |
| Gypsum Panels and Bases, Glass-Faced | 6.3E-06 | 0.015 | 0.030 | 0.075 | 0.120 | 0.135 | 0.150 | 0.180 |
| Gypsum Fiber-Reinforced Panels | 3.5E-06 | 0.008 | 0.017 | 0.042 | 0.067 | 0.076 | 0.084 | 0.101 |
| Gypsum Plaster, Sanded (100:2, 100:3) | 1.5E-06 | 0.004 | 0.007 | 0.018 | 0.029 | 0.032 | 0.036 | 0.043 |
| Gypsum Plaster, Wood Fiber (sanded 100:1) | 2.8E-06 | 0.000 | 0.013 | 0.034 | 0.054 | 0.060 | 0.067 | 0.081 |
| Gypsum Plaster, Perlited | 4.8E-06 | 0.012 | 0.023 | 0.058 | 0.092 | 0.104 | 0.115 | 0.138 |
| Gypsum Plaster, Vermiculite (sanded 100:2) | 3.8E-06 | 0.009 | 0.018 | 0.046 | 0.073 | 0.082 | 0.091 | 0.109 |
| Cement Board (50%-90% RH) | 1.0E-05 | 0.024 | 0.048 | 0.120 | 0.192 | 0.216 | 0.240 | 0.288 |
| Spruce Pine Fir (parallel to fiber) | 1.0E-06 | 0.002 | 0.005 | 0.012 | 0.019 | 0.022 | 0.024 | 0.029 |
| Spruce Pine Fir (perpendicular to fiber) | 3.2E-04 | 0.768 | 1.536 | 3.840 | 6.144 | 6.912 | 7.680 | 9.216 |

5%-90% RH (in./in./% RH)

**Effects of Poor Conditions on Gypsum Board Systems**

The following conditions may result from poor environmental conditions:

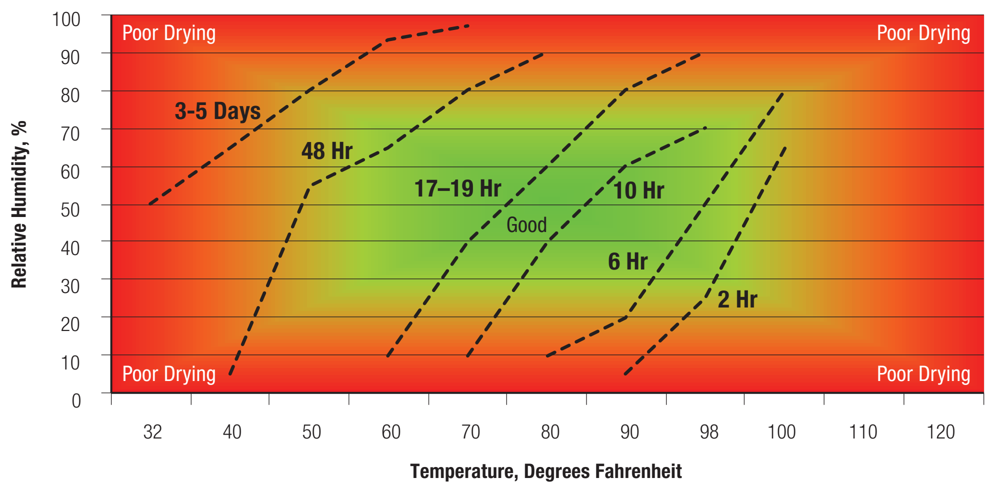
- Ridging—This is the result of hygrothermal expansion in which the movement causes adjacent panels to press tightly against each other. The resulting stresses are relieved by the panel edges bending outward in the region of the joint. It is a progressive deformation that appears as a continuous ridge along the length of the joint, with a uniform, fine, ridge-like pattern in the center.
- Starved Joints—Failure to allow time for the initial coats of compound to dry adequately results in poor drying conditions in which the subsequent coats of compound further delay the drying of previous coats. This causes normal compound shrinkage to occur after it was thought to be completed and the joint seems to have insufficient compound applied or appears "starved."
- Joint Edge Cracking—Cracks along the edges of the tape can be caused by too rapid drying due to high temperatures accompanied by low humidity or excessive drafts, or by cold wet application conditions resulting in poor bond.
- Joint Cracking—Cracks in the center of flat or angle joints are typically the result of some form of movement. That movement can be thermal, hygrometric or structural in form.
- Screw Depressions—These are low spots over the heads of nails or screws caused by a very slight swelling of the adjacent paper. This is caused by excessive humidity, free moisture and/or temperature creating poor drying conditions. The extended drying time causes the panels to absorb extra moisture, softening the core and causing the paper surrounding the fasteners to swell slightly. Large increases in relative humidity after the gypsum panels have been installed can also result in moisture absorption and slight swelling of the paper. Failing to use a graduated arc of compound or applying the compound flush to the surface will accentuate this phenomenon. Please refer to USG's Finishing and Decorating Gypsum Panels (J2010/11-10) for more information.
- Nail Pops—Caused by shrinkage in framing lumber. The tip of the fastener remains anchored in the stud as the surface of the stud shrinks away from the back of the gypsum board. This leaves the fastener extending out away from the framing with the panel slightly loose. Any pressure on the panel causes it to move back to the surface of the stud resulting in the fastener head pushing the joint compound covering it out away from the surface of the panel.
- Mold Potential—Poor job conditions create a greater potential for the growth of mold on building products. Excessive free water, high humidity, poor ventilation, and temperature extremes extend drying times, thereby exposing materials to elevated moisture conditions for longer than normal. Such abnormal exposures can result in conditions conducive to mold growth.
- Bond Loss—The absorption of excessive moisture into building materials can lead to bond loss as that moisture dries out. This can happen to moist panels where joint compounds, paint, or other wallcovering products have been applied.
- Final Appearance Defects—The final appearance of a wall or ceiling system can be negatively affected by poor job conditions. Varying drying times can lead to paint color/texture variations, sheen differences, joint telegraphing, and even bubbling of the finish paint in areas where the previous coat of paint still contains significant moisture.

Joint Compound Drying Time Chart

The color coded graph provides a simple reference to evaluate the risk levels at the respective temperature and humidity levels on the jobsite. It should be noted that the environmental factors vary from room to room on any jobsite and should be thoroughly measured. The colors indicate the relative drying conditions and the dashed lines indicate the various estimated drying times based on the relative humidity and temperature indicated. The chart is an approximate representation of the amount of time it will take for a single, nominal 1/16" coat of compound to dry. The time will vary based on the thickness of the compound and the amount of airflow/exchange that is occurring in the space. While the chart shows temperatures lower than 55°F, USG recommendations require that the temperature be maintained at or above 55°F during the entire finishing process and until the compound is completely dry.

**Joint Compound Drying Time**

As a function of temperature at specific relative humidity




### Optimal

Green areas are considered to be good jobsite environmental conditions that provide for efficient drying conditions. The likelihood of drying-related problems in this area are small.

### Marginal

Yellow-shaded areas are considered to be fair conditions for finishing but some finishing and decorating problems may occur. Slight ridging, hairline edge cracking, joint telegraphing, and slight screw depressions are possible. Failure to improve the jobsite conditions may result in the need to perform extra work or repairs to achieve a suitable finished appearance.

### Poor

Red-shaded areas are those conditions where stocking, hanging, finishing, and decorating operations should not be done. Problems will result and extensive extra work or repairs will almost certainly be needed.

**Risk Assessment Methods, continued**

Dew Point

Using the dew point temperature is another method of evaluating the jobsite environmental conditions. The dew point is the temperature at which moisture will condense on a surface. It is determined by measuring the temperature and relative humidity of the room air. No compounds or coatings should be applied unless the surface temperature is at least 5°F (3°C) above the dew point temperature of the room air and any ventilation air flowing over the surface. This requires measuring the surface temperature of the wall, as well as the temperature and relative humidity of the air, to determine its dew point. There are a number of inexpensive, portable devices for measuring this. It should be noted that the surface temperature must be maintained above the dew point throughout the curing process.

**Dew point calculation chart–Fahrenheit**

**Ambient air temperature °F**

| | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **90** | 18 | 28 | 37 | 47 | 57 | 67 | 77 | 87 | 97 | 107 | 117 |
| **85** | 17 | 26 | 36 | 45 | 55 | 65 | 75 | 84 | 95 | 104 | 113 |
| **80** | 16 | 25 | 34 | 44 | 54 | 63 | 73 | 82 | 93 | 102 | 110 |
| **75** | 15 | 24 | 33 | 42 | 52 | 62 | 71 | 80 | 91 | 100 | 108 |
| **70** | 13 | 22 | 31 | 40 | 50 | 60 | 68 | 78 | 88 | 96 | 105 |
| **65** | 12 | 20 | 29 | 38 | 47 | 57 | 66 | 76 | 85 | 93 | 103 |
| **60** | 11 | 19 | 27 | 36 | 45 | 55 | 64 | 73 | 83 | 92 | 101 |
| **55** | 9 | 17 | 25 | 34 | 43 | 53 | 61 | 70 | 80 | 89 | 98 |
| **50** | 6 | 15 | 23 | 31 | 40 | 50 | 59 | 67 | 77 | 86 | 94 |
| **45** | 4 | 13 | 21 | 29 | 37 | 47 | 56 | 64 | 73 | 82 | 91 |
| **40** | 1 | 11 | 18 | 26 | 35 | 43 | 52 | 61 | 69 | 78 | 87 |
| **35** | -2 | 8 | 16 | 23 | 31 | 40 | 48 | 57 | 65 | 74 | 83 |
| **30** | -6 | 4 | 13 | 20 | 28 | 36 | 44 | 52 | 61 | 69 | 77 |

Fahrenheit Example: Temperature of 70°F and relative humidity of 65% results in a dew point of 57°F. No compounds or coatings should be applied in this case unless the surface temperature is at least 62°F.

**Responsibilities**

It is the responsibility of the parties directly involved in the construction and finishing processes to insure that jobsite environmental conditions meet industry standards and the manufacturers' recommendations for the product(s) involved. This includes the architect/design professional(s), owner(s), general contractor, construction manager, and sub-contractor(s). Where multiple products or processes introduce different recommendations, the most critical limiting conditions must be identified and observed. It should be contractually established who has responsibility for jobsite environmental condition accountability. There should be an established procedure for determining the conditions in every area of the jobsite, monitoring those conditions, and maintaining a constant, acceptable environment. The best method for maintaining environmental conditions at acceptable levels during finishing and decorating is to use the central heating system (HVAC) of the building before, during, and after these operations commence. The environmental control systems in use should not be turned off after work hours or on weekends to avoid large swings in conditions, which would likely lead to problems. Use of unvented temporary heaters should be avoided. Unvented temporary heaters may produce fumes that can stain surfaces. These stains can then bleed through textures and paints to show on the completed finish. Unvented temporary heaters, such as propane or kerosene, also add water vapor to the air as they burn. This can significantly raise the humidity level and they typically produce uneven heat/humidity levels throughout the building. The biggest challenge with temporary heat is providing adequate ventilation so that the temperature and humidity are uniform and constant throughout the building. Heaters should not be allowed to blow directly on wall surfaces because excessive localized heating can cause rapid drying, leading to cracking and delamination. These challenges, and others, emphasize the need for a unified, detailed plan to address round-the-clock jobsite environmental conditions.

**Conclusion**

Controlling and maintaining environmental conditions is critical to minimizing potential problems during the finishing and decorating operations. These operations create the look and feel of the final space that the design professional intended and the occupants will utilize during the building's life. Failing to maintain good conditions during this critical phase of construction can create problems that will be costly and difficult to repair. In many cases, the costs of the repairs can exceed that of the original work. The closer your environment is to the marginal/poor range on the Joint Compound Drying chart, you significantly increase the chance that you will encounter some or all of the problems referenced in this document and perhaps more.

**References**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GA-236-00 Joint Treatment Under Extreme Weather Conditions, Gypsum Association. **www.gypsum.org**

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