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Technical Bulletin #9

Understanding and Controlling Condensation

Introduction

All too often, condensation and its prevention is not given adequate attention in building design and construction. The following is an attempt to explain condensation, what its effects are, and how it can be controlled.

Condensation and Its Terms

Air is composed of many gases. One of these is water in a gaseous from, called water vapor. The amount of water vapor that air can hold is a function of temperature. When the air comes in contact with an object at a temperature where water vapor will change to a liquid, it is known as the dew point temperature. This process is called condensation. Condensation is not a property unique to water vapor alone, most other gases behave in a similar manner. Unlike other gases, water vapor condenses in the temperature ranges which we find in buildings.

The temperature at which the air/water vapor mixture no longer retains its water vapor in the gaseous state is called the dew point temperature of the mixture. The dew point temperature is sometimes referred to as "dew point." The ratio of the amount of water vapor in air compared to the maximum amount air can hold at a specific temperature is called the relative humidity. When air is absolutely dry, its relative humidity is 0 %. When an air mixture has reached its dew point temperature, its relative humidity is 100%. The higher the relative humidity, the greater water vapor content of the air at that temperature.

Each component of the air mixture is driven by the partial pressure of each component. Even though water vapor can move independently of air, when air is heated or cooled, the water vapor should be considered as part of the air-vapor mixture. If air is exposed to changing temperatures, the air will be driven from an area of higher partial pressures to an area of lower partial pressures. One of the components of air, water vapor, is also acted upon by partial pressure. It is this natural phenomenon which moves water vapor though the air or any porous material.

Sources of Moisture

Moisture is given off in many different processes. Human beings give off a significant amount of water through respiration and perspiration. There are other common sources. Gas, oil-fired and propane space heaters give off a significant amount of moisture through the process of combustion. The moisture introduced through combustion is sometimes very difficult to detect because at the point of combustion, the gases are very hot and can hold large quantities of moisture. When this hot gas is mixed with cooler air, the temperature drops. As the temperature drops, the amount of moisture that the gas can hold will decrease and at some point away from the combustion device, the water will condense on anything that it comes in contact with that is below the dew point of that mixture. Flue gases should be vented outside to prevent this from happening.

Even before a building is fully completed, there can be significant amounts of moisture introduced into the building. Excavated earth contains a significant amount of moisture. As the soil is exposed to surrounding air, the moisture will be given off. If the building is closed, this moisture will stay within the building. As soon as the temperature drops below the dew point of that air/water mixture, condensation will form.

Fresh concrete is another source of large amounts of moisture. If the building is closed and concrete is poured, a way must be provided for moisture to be vented to the atmosphere. Ventilation should always be considered as a preventive measure during the construction schedule.

Effects of Condensation

Knowing the process by which condensation is formed, one can look at the effects of condensation on normal building materials. For the metal building industry, the most commonly used materials are steel sheathing and fiberglass insulation. Most of the metal in metal building is treated against corrosion and rust. Rust is a result of an interaction between the metal and salts, acids or alkalines. Another metal employed is aluminum which does not rust, but does oxidize. In both instances, the metal itself becomes weaker. In time, both materials will deteriorate and shorten life expectancy. While many surface treatments are applied to ferrous and non-ferrous metals to prevent oxidation, the best protection is to eliminate a principal cause of oxidation--in other words, eliminating condensation.

The insulating material most commonly used in metal buildings is fiberglass blanket. Water in its liquid form is a good conductor of heat. The presence of water vapor or condensed water in fiberglass insulations will increase its thermal conductivity because of the higher conductivity of water.

However, glass fibers do not absorb water. Only surface wetting occurs. Once all the moisture is removed from the wet fiberglass surface, it will revert back to its original insulating value. The same cannot be said for other materials. Here again, an ounce of prevention is worth a pound of cure. Eliminating and preventing condensation in the fiberglass will help retain the insulating values of the fiberglass.

Condensation Control

One way to control condensation is to exchange the high moisture content air with air having a lower moisture content. This is commonly called ventilation. Another method of controlling condensation is through the use of vapor barriers. Vapor barriers are used to limit the migration of moisture into the fiberglass and onto the metal sheathing. In the metal building industry, this is accomplished through the use of different types of facings on the fiberglass insulation. Vapor barriers do not stop vapor transmission, but they serve to reduce its movements. Because moisture travels from areas of higher vapor pressures to lower vapor pressures, the vapor barrier should always be placed at the point of the highest vapor pressure. This usually means on the inside or the warm side of the structure. The exception to this is when the interior of the building is a cooler or freezer and the inside temperature is lower than the outside temperature.

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A vapor barrier's effectiveness in controlling moisture movement is measured by its perm rating. This is a shortened form of the term "permeance." Permeance is defined as the rate of water vapor transmission through a material in a given amount of time per unit area. In U.S. customary units, a permeance of one perm is defined as 1.0 grains of water vapor transmitted per hour per square foot per 1.0 inch of mercury vapor pressure difference. The lower the number, the better the vapor barrier. Materials with perm ratings of 1.0 or greater are usually not classified as vapor barriers. Vapor barriers come in a wide variety of materials and perm ratings.

A vapor barrier is important because condensation can appear in two forms. The first is visible condensation, which occurs when condensation appears on surfaces that are adjacent to the warm side of materials. One can clearly see this. This type of condensation can form on windowpanes, purlins or thru-metal fasteners. This type of condensation, while it is a nuisance, is far less damaging than hidden condensation. This can be somewhat controlled by additional insulation or by reducing the relative humidity.

The second form of condensation is hidden or invisible. It can occur inside materials. Some examples of this would be the moisture that is absorbed by drywall, plywood, ordinary sheathing materials and the like. Fiberglass insulation will hold moisture either as water or water vapor that has condensed within the insulation.

Removing the moisture from within the material is a difficult task. Once the moisture is introduced into the fiberglass blanket, moisture is trapped between the steel skin and the vapor barrier. The result is that as the temperature changes inside the blanket, the water will go through a cyclic life of water vapor and condensed water. The only way that the moisture can be removed is if the temperature conditions are held long enough for the water to escape the blanket, either through the vapor barrier or openings in the barriers.

Summary

Because buildings are becoming more thermally efficient, both through the use of increased insulation thickness and designed to be more airtight than in the past, the control of condensation should be considered. Quality vapor barriers and correct insulation should be use to reduce the possibility of hidden condensation. Buildings should be designed and well constructed to prevent the entry of exterior water into the structure. If the relative humidities inside the buildings are high, ventilation should be considered as a method of control. Vapor barriers will not stop moisture transmission. They will only retard it. One way of reducing condensation is through ventilation and the reduction of the water vapor in the air.

Careful planning in the original design and evaluation of the building's use will save the builder and the owner many problems.

Notes: This Bulletin has been prepared to assist the metal building industry to understand and deal with condensation. Its contents are based on information believed to be reliable. However, the prevention and elimination of condensation depend on the design and construction of the building for which neither LFIPA nor its members can take responsibility. Accordingly, nothing in this Bulletin should be regarded as a recommendation concerning metal building design and construction.

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